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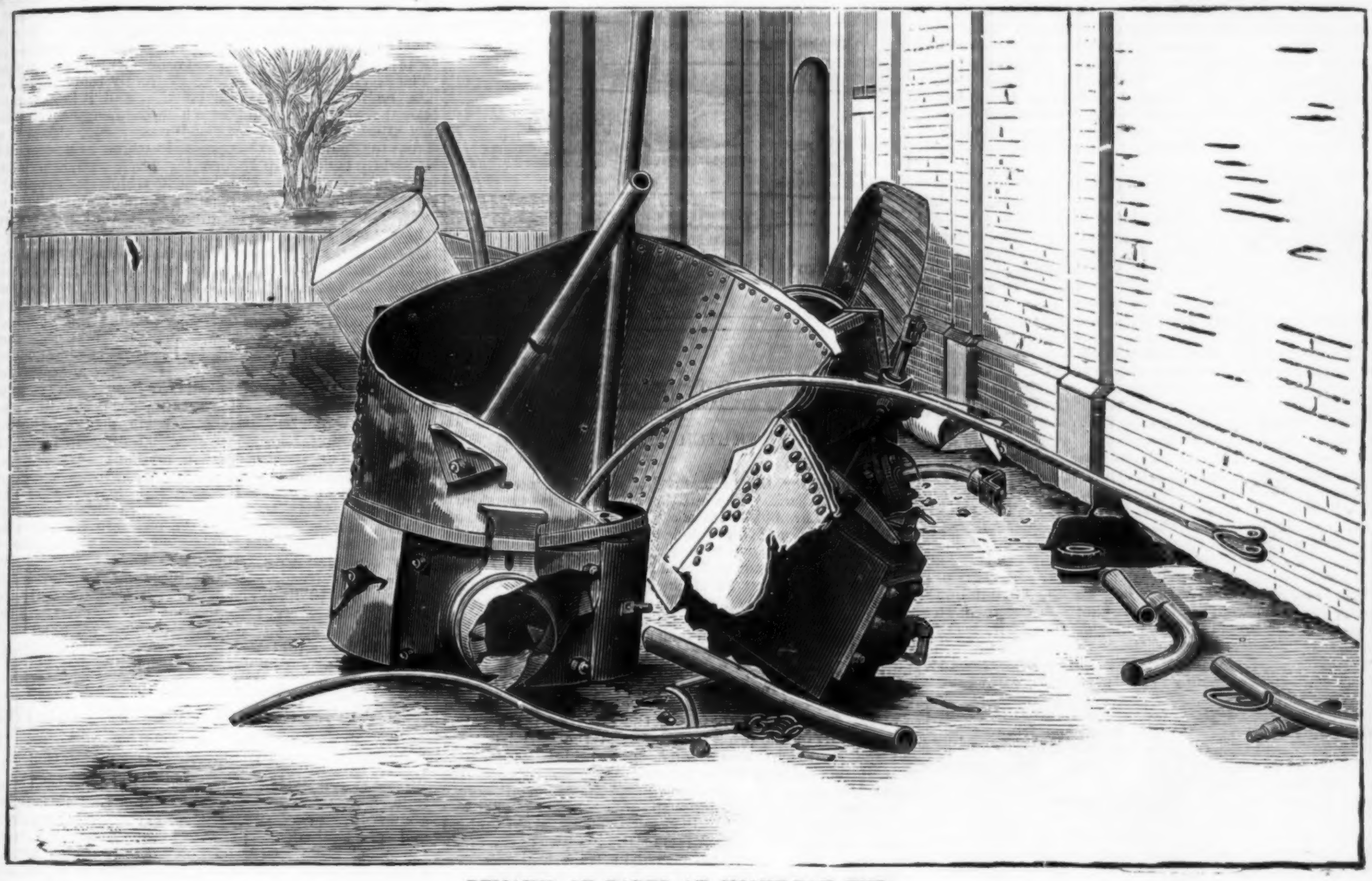
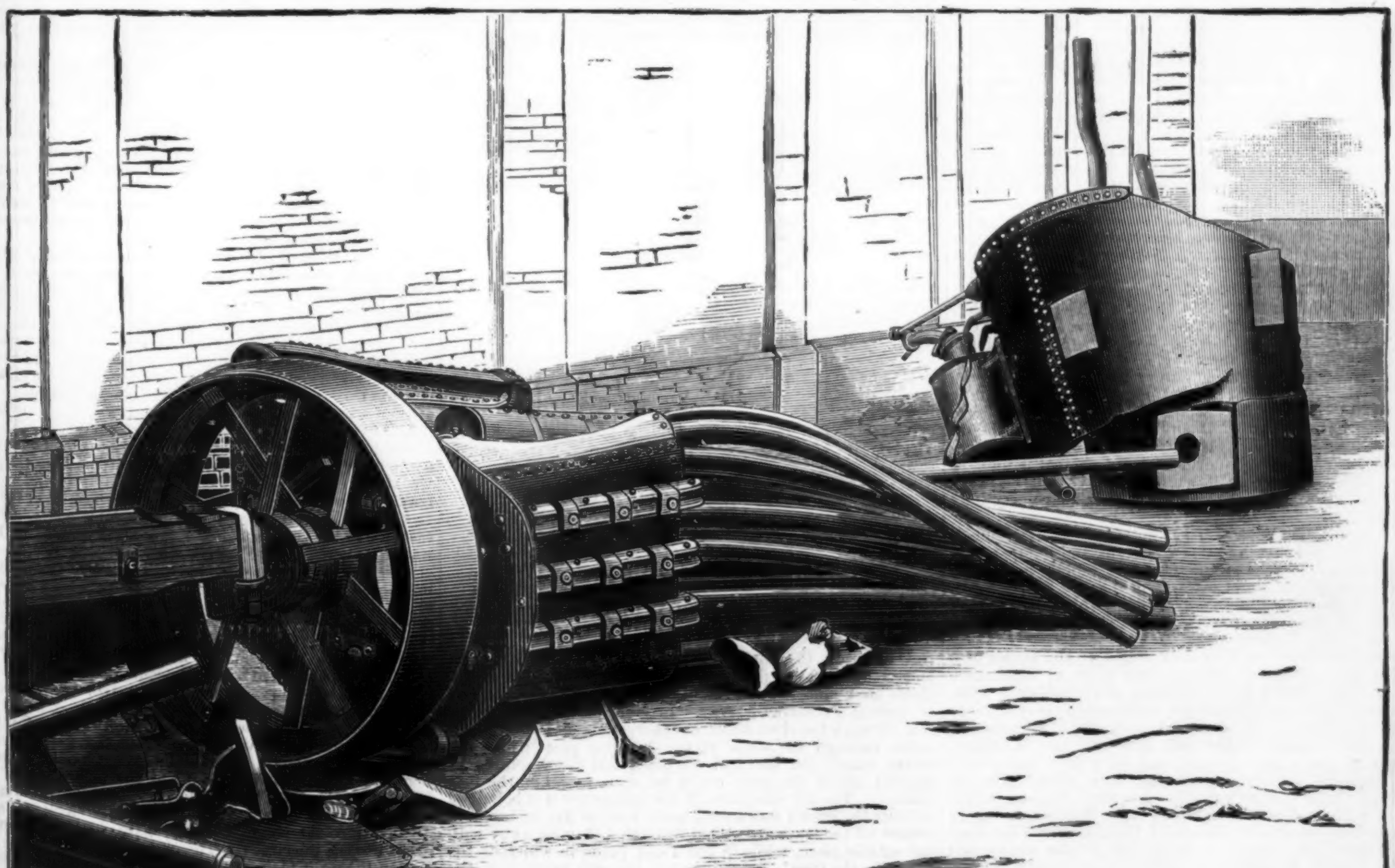


REMAINS OF PARTS AT SMOKE-BOX END.



REMAINS OF FIREBOX.

EXPLOSION OF A ROAD LOCOMOTIVE AT MAIDSTONE, ENG.

REMARKABLE BOILER EXPLOSIONS.

On Sunday, January 16, 1881, at 5½ P.M., a singular accident took place in New York city, at the corner of Broadway and Eleventh street, occasioned by the explosion of a sixty horse-power steam boiler, located under the street sidewalk on Eleventh street. The building to which the boiler pertained was the large and splendid edifice of the Methodist Book Concern. Eleventh street is sixty feet wide. The sidewalks and dwellings opposite the place of explosion were covered with mud and much glass was broken. The street, for a distance of two hundred feet each way from the boiler, was flaked with debris. The air was filled with the flying debris of iron, stone, bricks, mortar, and glass; the surrounding buildings were shaken as by an earthquake. When the clouds cleared away an immense hole was visible in the sidewalk, showing that one of the boilers used to heat the building had burst. The building measures 225 feet on Eleventh street, 75 feet on Broadway, and is five stories high. The principal lessees are James McCreery & Co., one of the oldest dry goods houses in the city. They occupy the main floor on Broadway, most of the basement, the larger portion of the second floor, and two upper floors, and employ about 250 persons in manufacturing and selling fine dry goods. The Methodist Book Concern occupy a space about twenty feet wide on Broadway and a part of the basement as a store for the sale of their publications. They have their offices and a large meeting-room in the second story. Packard's Business College occupies the third story.

The building was heated, and the freight and passenger elevators run, with steam generated in two boilers, which were placed under the sidewalk on the Eleventh-street side of the building. These boilers measured 16 feet by 14 feet 6 inches. They were of the tubular pattern, and were duly inspected by the proper authorities in October, and certificates granted for over fifty pounds pressure. It was the custom to bank the fires under the boilers every night and to keep them banked over Sunday. The engineer and firemen were in the habit of attending on Sunday to see that everything was right. The boilers stood side by side, and it was the one nearest the street that exploded. The part that gave way was the crown of the dome, a circular piece about 3 feet 6 inches in diameter, in which was the man-hole, about 15 inches in diameter. This crown was stayed to the boiler by eight stout iron braces, which remained attached to the boiler, all the ends of the crown piece having given way at once, leaving a clean edge to the fracture.

The force of the explosion was terrific. The hole made in the sidewalk was about fifteen feet square. The thick iron rafters that sustained the sidewalk were shattered. Huge blocks of the stone slabs were laid over the adjoining pavements. Part of the man-hole plate was shot as if by a cannon into a building across Eleventh street. Showers of iron scraps and bricks played havoc with the surrounding window-glass. Pieces of metal were shot upward through the iron coping of the building. Some of those who heard the noise say there were three distinct shocks.

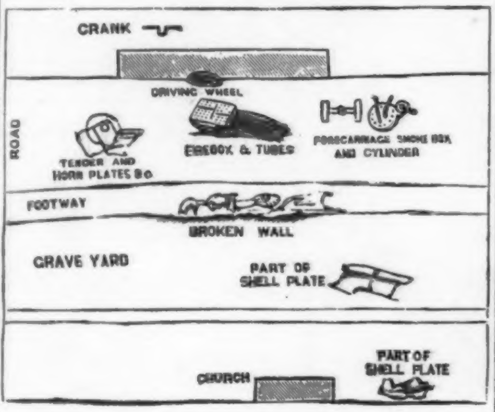
The most wonderful thing of all is that no one was injured. There were several persons passing in both Eleventh street and Broadway. The Rev. Mr. Dexter was covered with a shower of glass, but was not hurt. Four immense plate glass windows in the Broadway front of McCreery & Co.'s store were blown out, and their fragments were strewn on the sidewalk and roadway. The window frames and glass on the building immediately over the boiler all the way up were thoroughly shattered. The large hotel at 11 West Eleventh street, on the same side of the way, was considerably injured by the breaking of the ornamental iron-scroll work on the front of the capacious fire-escapes, pieces of which were shot off by the flying debris and carried into the house.

The engineer, Samuel Rushworth, who has been in charge about ten months, said: "I have had charge of boilers off and on for twenty years. I am a machinist by trade, and can give ample references as to my capacity as an engineer. I cannot give the slightest reason why this boiler should have exploded. I thought it was perfectly safe. We banked the fires every night, as is common with such boilers everywhere. I always came down on Sunday about two or three P.M., to see that everything was right. I came down as usual to-day. I found everything all right and safe. There was only three pounds of steam—nothing to speak of—on the boiler that exploded. There was fifteen pounds on the other boiler. The fireman, Jim Harrigan, was an experienced man. He was employed seven years in firing on these boilers. He was down here to-day and attended to them as usual, but went away. Neither of us was here at the time of the explosion. I am sure that only one boiler exploded; that was the one with the three-pound pressure on that was used for the freight elevator. The other boiler, which is still good, was used mainly for the passenger elevator, and could be used now, if necessary, as it is unhurt. I have no suspicion that there was anybody tampering with the boiler. The watchman, Carey, was up stairs in the store at the time, and I do not think he would meddle with anything. The fires were left as they always have been, and I do not know of any reason why there should have been an explosion. I have attended boilers and engines in other places and never had an accident before. I was not obliged to come down on Sundays, but I always did it as a precaution, and to make sure that everything was right."

The cause of the explosion has not yet been ascertained, but it is believed that by some oversight the dampers and doors were left so that steam would be rapidly generated, while the supply of water was cut off.

We will now describe an explosion which lately took place in England, the particulars of which, with engravings, we find in *The Engineer:*

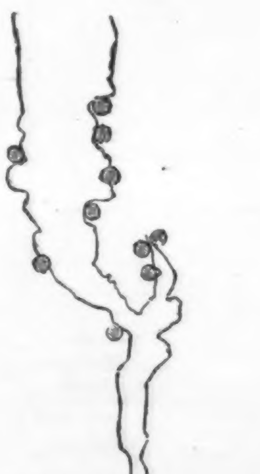
A most destructive and fatal explosion of the boiler of a traction or agricultural engine took place at Maidstone, Eng., at three o'clock in the morning of December 3, 1880. The steersman was killed and the whole engine as effectively blown to pieces as if charged with a quantity of gunpowder, considerable damage being also done to the All-Saints Church, to the burial ground, and to a large carpenter's shop, opposite which the explosion took place. The engravings which we give herewith, prepared from copyright photographs by Messrs. Clarke & Co., of Maidstone, supply some idea of the destructiveness of the explosion; but they cannot show how completely every part of the engine has been destroyed, wrought iron being torn as though it were paper, and heavy cast-iron wheels and other parts broken up like pottery ware. The engine had proceeded with its load, consisting of two wagons, each loaded with about five tons of manure, up the hill of Maidstone High street, and had turned down a narrow street, named Mill street, and had proceeded as far as the church and the carpenter's shop. Here the man who led the way ahead of the engine with a lamp observed that one of the lamps on the engine was extinguished, and went back to the engine, which was stopped for relighting the lamp. The stoppage was but for a few minutes, and on re-starting the engine, which made about one revolution, according to the testimony of the driver, who lies in the hospital much injured, the boiler exploded with terrific force. The High street is a gradient of some steepness, while Mill street is a similar descent, there being again a slight ascent to the church. The explosion was such that it is impossible to imagine any more complete destruction. The engine was an eight-horse power nominal, and was built three years ago. The explosion separated the engine into five principal portions. The plan on the front page will assist us to explain this, although only a rough sketch. At the time of the explosion the engine was nearly opposite the church, and on the left side is the carpenter's shop, marked A. The explosion drove the tender and the hinder parts of the outer fire box, carrying the horn plates—to which are fixed



SKETCH PLAN.

the bearings for the main driving axle and intermediate shaft—a little back. The remains of these parts are shown above. The fire-box, with most of the tubes, was blown out, shattered, and deposited in the road about 30 ft. further on, while the fore carriage and smoke-box plates, front tube plate, and shattered cylinder and other parts were deposited about 12 ft. in advance. The two larger pieces of the boiler shell were blown up and into the burial ground to the position shown, breaking several grave stones in their path, one stone slab being lifted from its seat and shattered. One portion of the shell was blown nearer the church than the other. Several large fragments were driven much greater distances, and the crank shaft was blown over the carpenter's shop. The heavy gear wheels were broken to pieces, and parts of these and the other parts destroyed several yards of the brick wall between the burial ground and the roadway. The steersman was blown up about 30 ft. through a tree, where his coat was torn off him, and descended about 35 yards away, probably dead before he reached the ground, though the watch in his pocket was afterward found to be still going. The fine old stained glass window in the church facing the road was very much damaged, part of one of the eccentric straps still hanging, on Friday afternoon, on one of the iron bars of the window, while other projectiles entered the church, one piercing the organ case.

In examining the remains of the engine, it seems evident that an enormous pressure must have been in the boiler.



RENT FIREBOX PLATE.

Not only are the shell and outer fire-box plates torn in pieces, but the single butt strips with which the boiler plates are connected and the heavy plates at the fire-box end are torn in a remarkable way. In some parts the plates are rent through the rivet holes, in others along close to the butt strips through the whole plate. In every place where the steam, water, and dirt had not blackened the fractured or sheared edges the iron could be seen to be of the best quality. The off side plate of the inside fire-box is bulged in from the crown downward about four or five inches, and almost all the stays are pulled through and gone away with the outside plate, while in the front plate, in which is the fire hole, the iron is bulged inward between every stay, the stays being five inches apart. The near side plate is rent from top to bottom, the lower part of this rent being roughly indicated by the annexed diagram. In this plate there had been one, or perhaps two or three short cracks, and, to stop these and prevent their extension, about ten studs had been tapped in and riveted over in a manner which is often inadvisedly followed. This had been done by the proprietors, Messrs. Ellis & Co., of Maidstone, who are the owners of, now, about twelve such engines. In the line of some of these studs this plate had torn, the position of the studs being approximately as indicated. It would be difficult to say how far this studding may have contributed to the disaster, but the way in which the opposite plate is bent and bulged in, and other plates have been rent, indicates that it was not the cause of the explosion. It is noticeable that but few of the stays have broken, while in some cases most of the threads have stripped from the plates, and in others most have gone from the stays. If the faulty plate had been very materially weakened or insufficiently supported by the stays the excess of pressure would probably have been relieved here; but the complete destruction of other parts shows this was not the case. The tearing of the plates, particularly of the shell, indicates a powerful destructive force, which, being checked by stiffer parts, tore the plates at those points just as guns go at the meeting places of thicker and thinner sections. Although, moreover, we have spoken of the plates as being torn, they have the appearance in many places of being separated by a breaking or shearing force, as though the active destructive power was too great and operated too quickly to permit of tearing. The driver has stated that he distinctly remembers feeling the engine lift first on the off side, and it is in support of this that the hinder part, to which the heavy driving wheels are attached, is turned over on the near side. The off wheel from that part of the bearing axle which is uppermost was evidently thrown up against the brick wall, which is considerably damaged, and against which it dropped and stands. The axle, big as it is, is much bent. The piston rod, which still holds part of the crosshead, is bent over, as shown, and the screws on the spring balances, which have been found, are so bent over in the fall under the weight of other parts as to prevent the removal of the nuts, so that these will indicate how the balances were screwed down. This explosion is one which must have an important influence on the regulations under which these engines are worked, and there is now an enormous number of them in operation, and in the Maidstone district they are almost as numerous as horses, one firm of owners alone possessing thirty-five. These engines must by law be worked at night, when the men cannot see what they are doing, and there is no one to watch or supervise. Again, many of the men to whose charge these engines are committed, instead of being certificated engine drivers, can neither read nor write, and in some cases cannot read the figures on the pressure gauges. This is so well known that a red mark is placed on the gauges at 100 lb. to indicate the pressure over which the engines must not work. Again, men are open to a fine of £10 if steam is allowed to blow off when passing through a town, and thus with boilers that have to work at 100 lb., the safety valves are set to blow off, as they leave the makers, at 110 lb. The boilers are thus regularly worked at this pressure, and the ignorant drivers get the idea that if the valves are purposely set to blow off at 10 lb. above what they are told they must work at, they may, if they want, work at a good deal above that pressure.

A SUCCESSFUL AQUEDUCT OF LEAD PIPE.

By R. FLETCHER, Prof. of Civil Engineering, Thayer School of Civil Engineering, Dartmouth College.

INFORMATION relating to aqueducts of considerable magnitude, *i. e.*, exceeding six inches or a foot in diameter, is abundant and accessible, both as to theoretical requirements and practical details; but in the numerous treatises, "papers," reports, etc., on water supply which are known to the profession, little or nothing is given in regard to lines of small magnitude, *i. e.*, from six inches down to two inches or less in diameter, suitable for villages and small communities. Whatever practical experience has been gained in various parts of the country is known, generally, only in the local circle of those directly interested.

Undoubtedly there are many villages of a few hundred inhabitants in which the necessity for a systematic water supply is keenly felt, but the accomplishment of the desired end seems to be impracticable. Perhaps there are not a few where all conditions are favorable for securing this boon, except mistaken ideas concerning the magnitude, cost, and financial future of the undertaking. It may be that in many such cases, if definite results of experience in other communities could be made known, enterprising persons would be glad to execute what would prove a great public benefit, as well as a profitable investment for themselves.

With the hope of offering such incitement and of showing how readily such benefits may be secured, even on a small scale, the writer presents a brief history and description of an aqueduct line of lead pipe, one and a half inches in diameter, which has been in successful operation more than half a century. This service has required no expensive reservoir, no excessive outlay for maintenance, and has paid good dividends on the investment. The village of Hanover, Grafton Co., N. H., the seat of Dartmouth College, is situated on a terrace or plain about half a mile distant from and from 140 to 170 feet above the Connecticut River. The site is divided into two parts by a rocky ridge which culminates in "Observatory Hill," about 100 feet higher than the plain. On the west of this ridge some attempts to dig wells of reasonable depth yielded no result, and those that have been successful generally give hard, disagreeable water. On the east side of the ridge are only a few wells which afford good water. Therefore the supply from wells was not adequate or satisfactory. Manifestly the altitude of the plain made it impossible to draw from the river, except at an expense not to be thought of by a small community. The population probably seldom, if ever, reaches an aggregate of 1,000 persons, including visitors and students in attendance at the college and the professional schools. In former years the number of permanent and transient residents was not so large as at present. Hence the problem was to secure a sufficient but moderate supply of good water at an expense which a small and not wealthy community could afford.

After considerable investigation a sufficient source of supply by springs was found, and the Hanover Aqueduct Association was incorporated by an act of the Legislature of New Hampshire, Dec. 12, 1820. During the following year the association was organized with a capital stock of $5,000 divided into 50 shares. Each share sold was regularly deeded to the purchaser. The charter secured to the association the right to dig a trench through any land which it was necessary for the line to traverse, to reopen the trench for repairs, to change the position of the line, etc., rights indispensable to the laying and subsequent supervision of the aqueduct. During the sixty years of its existence the association has met all expenses for maintenance, including occasional extensive repairs, renewals, and enlargements, and

realized an income of from eight to ten per cent. on the investment. At intervals of eight to ten years, when unusual outlays exceeded the amount of any accumulated surplus, it has been necessary to pass dividends for one or two years.

SOURCE.

The source of supply, to describe it in its present state, is a series of four wells or springs near the foot of a steep wooded hillside, where the soil is saturated with water over a considerable area. The association now controls 35 acres of the slope above and around the wells. The latter are from four to six feet in diameter and from eight to twelve feet deep, lined with stone laid without mortar. From three of the wells the water is led to the fourth and lowest one, whence it passes into the aqueduct pipe through a strainer of sheet metal with fine perforations. These wells were never known to fail in the driest seasons, and there has always been a large amount of waste water, forming a considerable rill, flowing from the ground in the vicinity of the wells, since they were made. It is proposed to retard and retain this surplus, if future demand should require, by building a deep trench wall of stone and cement along the foot of the slope and just below the wells, and thus to increase the reservoir capacity without great expense.

THE LINE.

This is about two miles long from the wells into the heart of the village. After leaving the main well the pipe descends about 60 feet in the first 1,000 feet, when it crosses a brook, which at this point flows over a bed of solid granite. The pipe is carried across in a box of plank, laid on the rock and held in place by large bowlders. Although this box is seldom wholly submerged, only when the brook is running very full, there has never been any trouble by freezing, even in the severe climate of this part of New England, where the thermometer sometimes indicates 35° below zero (F.). From this point we will describe the line as it was previous to October, 1880.

After the above mentioned brook is passed the surface is much broken by knolls and gullies, so that a level line must be very sinuous. The generation which laid the first line, moved perhaps by false notions of economy, or being very straitened as to means, made the course as direct as could be tolerated, and heroically surmounted the knolls and descended into the gullies, making thus, in course of a mile, several vertical bends in the pipe, and causing differences of level of from five to fifteen or twenty feet. About 6,000 feet from the springs the spur of what is called "Sand Hill" is passed, and the line then rapidly descends about 70 feet in the next 2,000 feet to the borders of the village. Here the pipe is about 110 feet below the springs. It then ascends into the village about 50 feet to the highest point of delivery, so that at such point the hydrostatic head from the springs is from 50 to 60 feet.

So large was the friction head, and so great the obstruction to flow caused by accumulation of air and other consequences of the faulty vertical alignment just described, that at the higher points of the village there was occasional interference with the regularity of delivery, even with a total head of 60 feet, a far less efficiency, indeed, than might have been secured under the ordinary condition of the *hydraulic head*.

The weight of the old pipe was as follows: 2½, 3, and 4 lb. per foot for heads, respectively, of 50, 80, and 95 to 110 feet. In those days it was made in short lengths of about 12 feet; hence required a great deal of jointing. The weakest points of the old line were the joints, which were not made with sufficient care and thoroughness.

THE SERVICE OR OPERATION.

A few years ago, in anticipation of an enlargement of the capacity of the aqueduct, the main line within the village limits was renewed by a two-inch pipe in place of the one-and-a-half-inch before used.

The branch and service pipes have diameters of one-half inch and less. The system of delivery is that of gauges. Into the end of each service pipe is soldered a copper butt, which has a square termination detachable by means of a screw joint. In this removable end is a small hole sufficient to admit the passage of a medium sized sewing needle.

The daily allowance to each consumer, or one "share," is forty gallons, but under ordinary conditions the actual delivery exceeds this amount. The consumer provides means for receiving and storing the supply, generally by a good cistern of greater or less capacity. The ordinary requirements of a small family usually leave a surplus so that a large cistern can be kept full when the line is in good working order, and this reserve be made available in times of temporary stoppage or deficiency in the flow. In cases where consumers require more than one daily share, and endeavor to obtain it by tampering with the gauge, either by removing the end or enlarging the orifice, a fine is imposed. Formerly the higher points of delivery were very sensitive to any such interference, as a small diminution of pressure would stop the flow there at once. In all cases of stoppage or interference of flow by accumulation of air, tampering with the line at one or more points, accidents, etc., the services of an *overseer* are called for to apply proper remedies. This functionary, having acquired a thorough acquaintance with the line by years of service, generally is able to discover at once the cause of any difficulty. He makes occasional inspections of the points of delivery, besides, so as to see whether all is in proper working condition. For all such labor the association pays him by the day or hour for the time actually employed. The overseer acts under the orders of a general superintendent, who authorizes whatever is to be done. The other officers are such as usually constitute similar organizations, and they serve without compensation. The number of "shares of water" furnished by the line at the beginning of the present year was about one hundred and fifty, each nominally forty gallons per day. The charge per share was originally six dollars yearly, increased during several years past to eight dollars, but recently reduced to six dollars.

The water is excellent spring water, containing a sufficient amount of carbon dioxide in solution to cause a rapid formation of carbonate of lead upon the interior of the pipe. No case of lead poisoning has ever occurred in Hanover from the use of the water supplied by the aqueduct. Specimens of the old pipe which have been in use fifty-two, twenty-six, and three years have this inner lining of insoluble carbonate well developed, and careful weighing of old pipe which has been recently taken up does not reveal any diminution of weight, even during the longer periods of service.*

A NEW LINE OF PIPE.

The old line of one-and-a-half-inch pipe has not been adequate to the demands of the village for several years past. There was a continual waste of water at the wells, forming quite a rill even in dry seasons. Doubtless the delivery would have been much larger through the same pipe, if a better profile had been adopted. The association determined to relay the entire line with two-inch lead pipe, and this was successfully accomplished during September and October of this year. The means were obtained by increasing the capital stock from $5,000 to $10,000. Great attention was paid to securing a good profile. Throughout the mile of old line where the vertical bends were so numerous and frequent, the new line was laid practically level, although to accomplish this end it was found necessary to increase the length and at one point to dig the trench from eight to fourteen feet deep for about 300 feet. The weight of the pipe is seven lb. per foot under a head of 60 feet, eight lb. under a head of 60 to 80 feet, and nine lb. per foot under a head of 90 to 110 feet. Cost of new pipe about 6·2 cents per lb., delivered upon the ground. Cost of digging trench and laying pipe, about $1.50 per rod, or about $9.00 per 100 feet. The wages of laborers, $1 25 per day. The average depth of trench, four feet. An entirely new trench was dug, as the old line could not be disturbed until the new line should be brought into use. No blasting of rock was necessary, but numbers of large bowlders were encountered and removed by a machine consisting of a combination of geared wheels suspended from a tripod and worked by an endless chain. The new pipe was delivered on reels in lengths of 100 feet, and rolled off from the reels directly into the trench. The joints were made by swedging one end and inserting the other chamfered end about two inches, and for each joint about six-tenths of a pound of solder was used. Iron pipe would have been cheaper as to the pipe itself, but would have cost more when laid. Moreover it presented objections, viz., too great rigidity as compared with lead, far more numerous joints, necessity for laying it in straight lengths, rusting, etc.

When the water was first turned into the new line the time required for it to traverse the first 6,000 feet, including a descent of 60 feet in the 1,000 feet nearest the well, an ascent of four or five feet at the brook, and 5,000 feet on a level, to the regulating valve on Sand Hill, was almost exactly half an hour. The last 3,000 feet to the valve on the outskirts of the village, including a descent of about 55 feet and a rise of about 30 feet, was passed by the head of the stream in a little more than 20 minutes. With the same velocity of flow as in the old pipe the capacity of the new would be to the old as sixteen to nine. Considering the diminished friction, improvement of the profile, etc., the least sanguine anticipation was that the new line would deliver between two and three times as much water in given time as the old line did; but the actual capacity proves to be even greater, from three to four times. Indeed, under full pressure the old gauges would furnish more than three times the usual allowance, and it has become necessary to keep the regulating valve turned down to within one turn of an entire closure, whereas nine more turns are required for a full opening.

The old pipe was dug up at a cost of about 30 cents per rod, or $1.80 per 100 feet, and netted about $1,000 for the entire line of 9,000 feet.

There is reasonable expectation of an increase of 30 per cent. immediately in the number of consumers, and those who have undertaken this enlargement and improvement will receive substantial return, besides the pleasure derived from the conciousness of having directly contributed to a beneficent work to the lasting benefit of the entire community.

CONCLUSION.

Doubtless there are hundreds of villages throughout the country which are abundantly able to provide for themselves, in a similar manner, an equally good or even better supply of the best water. Wherever the proper conditions exist, a little energy and public spirit, exercised even by a few individuals, will suffice to accomplish so desirable a result.—*Engineering News.*

* Specimens of the old pipe, showing the inner coating formed as well after three as after fifty years of use, may be seen at the rooms of the American Society of Civil Engineers, 104 East Twentieth Street, New York City.

HYDRAULIC RIVETER FOR SHIPS' KEELS.

THE hydraulic keel riveter which we illustrate was one of the novelties seen by the members of the Institution of Mechanical Engineers, when they visited Barrow-in-Furness in August last. Everything at Barrow is on a large scale, and Mr. Humphrys, the manager of the Barrow Shipbuilding Company, has, in a thoroughly characteristic and energetic manner, gone into the question of hydraulic power as applied to shipwork on Mr. Tweddell's well-known system, and although we confine ourselves at present to a notice of one machine only, namely, the keel riveter, we trust at some future date to be able to lay before our readers full particulars of the extensive plant of hydraulic machine tools in use at the Barrow Shipbuilding Company's works.

HYDRAULIC RIVETER FOR SHIPS' KEELS.

We will now proceed to describe the keel riveter as illustrated on this page. In the first place a short length of tramway is laid under the vessel and alongside the keel, and upon this travels a bogie or carriage carrying the riveter. This riveter, as shown in the illustration, is attached to one end of a pair of levers, and is balanced by a counterweight on the other end. Thus balanced the riveter is easily moved up and down as required to meet not only the varying heights of the keel from the ground level, but also the different positions of the rivets themselves. The arrangement of levers is attached to a small carriage, which is free to travel inwards and outwards along a pathway on a species of turntable, and this turntable is supported on a large pin which is free to revolve on a socket on the traveling bogie or carriage.

By this means the riveter can be readily moved to or from the keel bar, which is sometimes necessary owing to the rails not being laid exactly parallel to the keel, and to other causes, while the whole apparatus can be turned round on its carriage.

It will be observed that there is a bandwheel behind the cupping die on the "hob" of the riveter; this turns a screw, which takes the thrust of the die upon closing a rivet. By this means, when the hot rivet is put in, the screw being turned inwards, a slight pressure is brought to bear on the rivet head, and the machine is thus steadied in position. Keel rivets, as is well known, have very shallow heads, the rivets also being countersunk, hence the necessity of some such contrivance as this to insure fair work. It will be observed that the riveting die is close to the top of the cylinder; this is a great advantage, since the gar board strakes often come nearly at right angles to the keel,

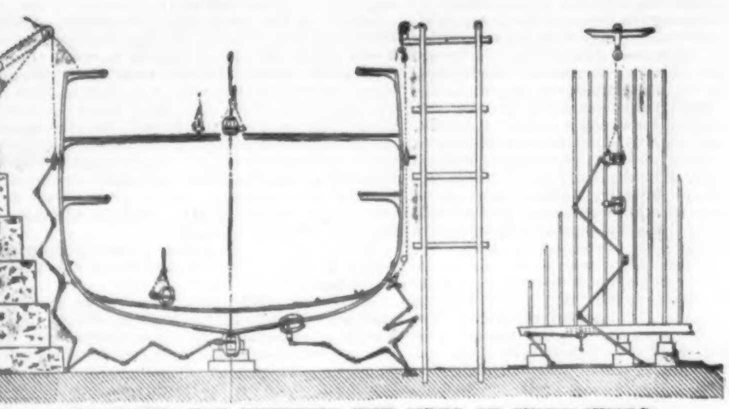
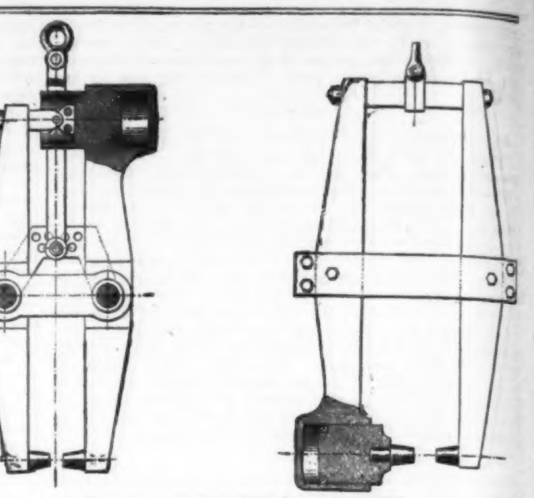


FIG. 1.—APPARATUS FOR RIVETING THE SIDES OF SHIPS' HULLS.



FIGS. 5 AND 6.—ARROL'S RIVETER.

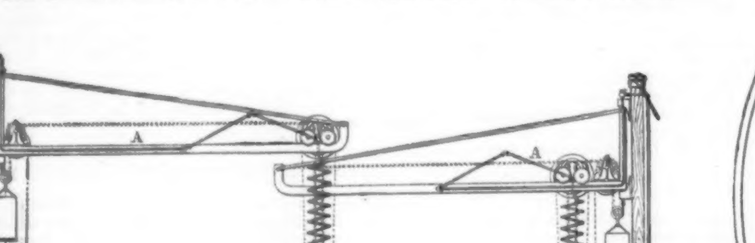


FIG. 2.—ARRANGEMENT FOR RIVETING SHIPS' FRAMES.

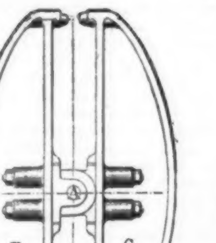


FIG. 4.—McKAY'S RIVETER.

FIG. 7.—FIELDING'S RIVETER.

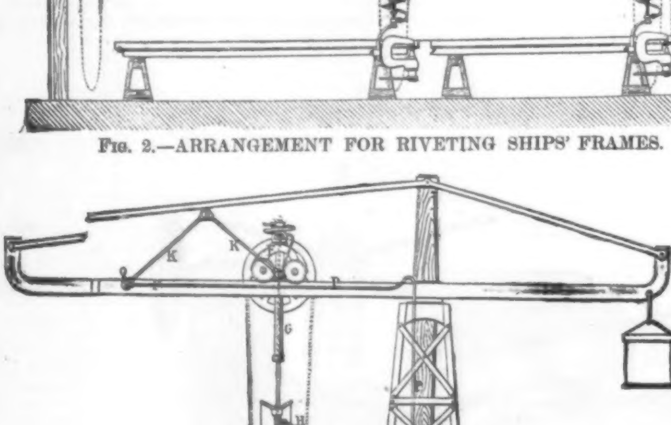


FIG. 3.—MOVABLE CRANE CARRYING A RIVETER.

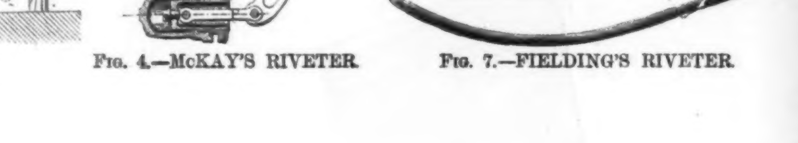


FIG. 8.—APPARATUS FOR RIVETING KEELS.

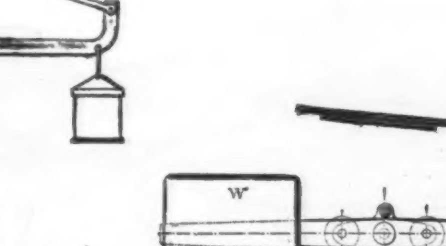


FIG. 10.—MACHINE FOR CURVING ANGLE IRON.

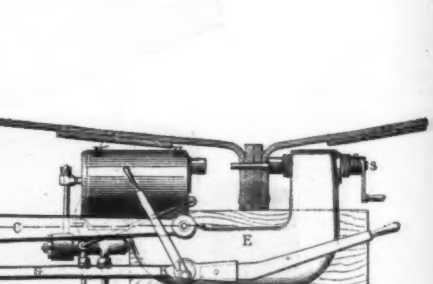


FIG. 11.—MACHINE FOR CURVING ANGLE IRON.

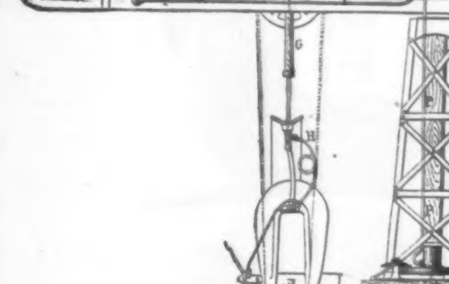
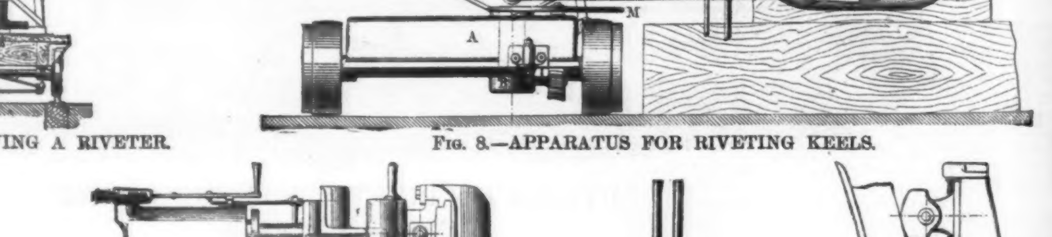


FIG. 9.—FIELDING & PLATT'S PRESS FOR STAMPING IRON PLATE.



FIGS. 12, 13, AND 14.—TWEDDELL'S RIVETER.

HYDRAULIC MACHINE TOOLS FOR SHIP-BUILDING.

The keels of the large steamships City of Rome and Servia among others, have been riveted by these machines, and no one who has seen sections of the work done and their thickness would ever think of trusting to hand-riveting for such important work. It is now many years since we were the first to illustrate and describe Mr. Tweddell's proposals as to riveting ships' keels and frames, etc., and we must congratulate him on the gradual accomplishment of his ideas.

There are of course other ways of applying hydraulic power to keel riveting on Tweddell's system, but this machine we illustrate is the most recent, and it has been constructed from the joint designs of Mr. Tweddell and Messrs. Fielding & Platt, the makers.—*Engineering.*

HYDRAULIC MACHINE TOOLS FOR SHIP-BUILDING.

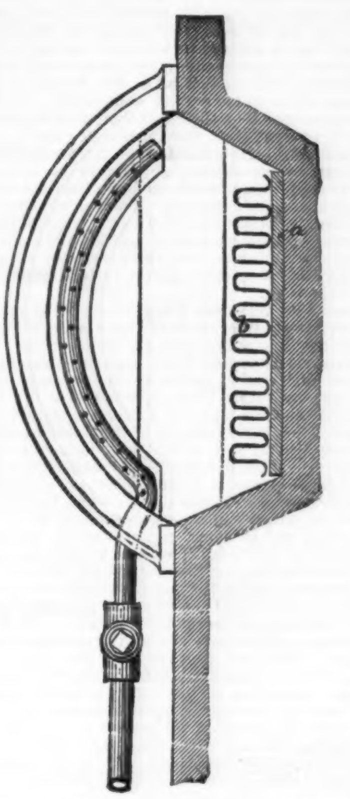
We give herewith an abstract of a communication made by Mr. Tweddell to the Society of Engineers and Ship Builders, of Scotland, on the application of hydraulic machine tools in the construction of naval vessels. The opposite figures show the principal types of apparatus described, and the most advantageous way of arranging them for use.

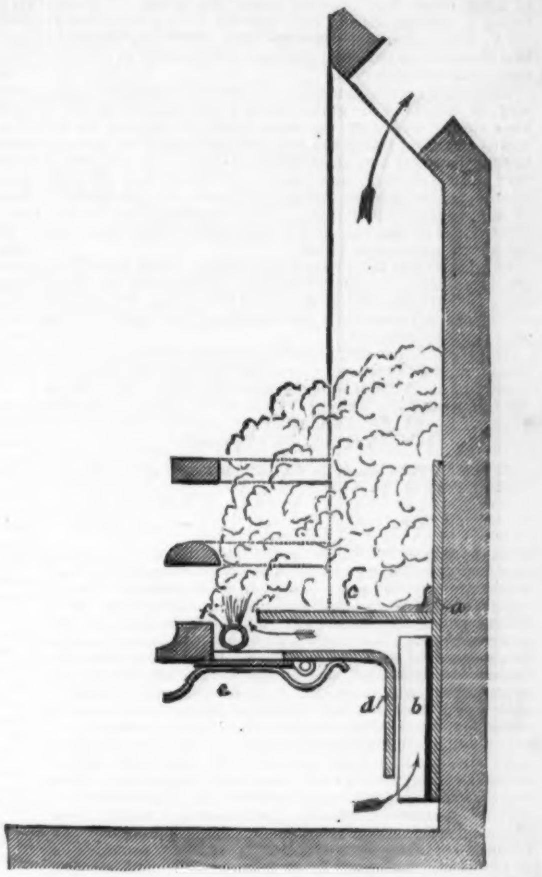
Mr. Tweddell's memoir begins with a historical exposé of the applications of compressed water as a motive power. After mentioning the hydraulic engines of the Egyptians and the discovery of Pascal and Bramah, the author points out the use of a hydraulic lifting jack by Mr. Murray, of Leeds, in 1810, and the patent for an accumulator taken out by Sir Charles Fox in 1847, or three years before Sir William Armstrong made the first application of his accumulator. In 1845, in a patent on a steam riveter, Garforth pointed out that steam might be replaced by air or water under pressure. In 1846 May patented a hydraulic machine for punching and riveting, which, however, was not put to any practical application. Fox was the first to use a hydraulic press for shaping iron and iron plate, and as a substitute for the steam hammer. As well known, numerous applications have been made of this method of making iron in France, England, and Austria since that time. In 1853 John Bourne patented a portable hydraulic riveter, but it had no more success than May's. In 1864 Mr. Tweddell constructed a hydraulic apparatus for fixing the extremities of tubes in tubular iron plates, by the use of which sixty tubes per hour could be put in place. The following year he designed for a New Castle house a stationary riveter. The results obtained from this last machine, both from the standpoint of economy and superiority of work, assured its success, and it rapidly came into use in the government workshops and in large manufacturing establishments. The first application of portable riveting machines in naval workshops dates back to 1872, when they were employed for riveting ships' frames by Messrs. Fielding & Platt, of Gloucester. One machine put in 1,000 rivets in ten hours' time. Figs. 1 and 2 show the arrangement of the apparatus either for riveting frames lying flat on horses, or for riveting lap-joints when the frames are mounted on the keel. To rivet the frames two stationary cranes, A A (Fig 2), may be employed. These carry the riveters, which work over the whole extent embraced in the swing of the jibs of the crane. A movable crane mounted on a car may also be used, and this may be moved around wherever needed. For riveting the sides of a ship the apparatus are suspended from the extremity of movable cranes located on the top of the walls of the dry dock (Fig. 1), or scaffoldings may be employed on which are stationed the men who operate the machines. However, the arrangements may be modified in each case to suit the conditions under which the work has to be performed. In the movable crane carrying a riveter (Fig. 3) the compressed water is taken from a metallic conduit placed under ground. To a stop cock, A, are fastened the pipes, B and B, which, by spreading apart, allow of the displacement of the crane. These pipes connect with a universal joint, C, which is connected with another like joint, E, by the pipe, D. From this point starts the pipe, P, which carries the compressed water to Q, where two extension pipes, K K, lead it to the hydraulic cylinder, G, which is carried by the car, F. The water under pressure finally reaches the riveter through the copper pipe, H. In the McKay riveter (Fig. 4) the two levers, B and C, work around a central axis, A, like the blades of a pair of scissors. Figures 5 and 6 represent Arrol's riveters. The second of these apparatus (Fig. 6) is analogous to the one employed by Mr. Tweddell in 1873 for riveting in place the trusses of Primrose Street bridge in London. In the Fielding riveter (Fig. 7) the hydraulic piston and its cylinder form an arc, having for its radius the distance from the axis, A, to the axis, B, of the cylinder. The apparatus employed for riveting keels (Fig. 8) consists of a car, A, on which there is a pivot, B, supporting a turntable. On the latter are fastened to the car, D, the levers, C, which carry the riveter, E. The riveter may be raised and lowered to put in place the different rows of rivets, its weight being counterbalanced by the weight, W. The rod, G, and the small eccentric, K, serve to keep the apparatus horizontal. This machine is now being used in the dockyards on the Clyde for riveting the keels of large ships, and does its work much better than the same can be performed by the hands of workmen. Messrs. Fielding & Platt's press for stamping iron plate (Fig. 9) consists of two braces, A and B, to the lower of which is fixed a matrix, D, of any desired shape. When the movable part, E, descends under the pressure of the upper cylinder, the plate is enchased between the two parts of the matrix. In order to prevent the torsion or flexure of the plate there is adapted to the upper part of the apparatus a second hydraulic cylinder, which supports a table serving to keep the plate against the bottom of the movable part, E, while this portion of the matrix is descending. Mr. Tweddell believes that hydraulic machines must come into general use for punching, riveting, and cutting iron plate, since in water pressure apparatus there exists no expense for motive power so long as the machine is not working uselessly, while in machines actuated by belts there is a constant loss of power in moving the driving shaft, the belts, and vacuum engines.

Mica has been applied to a new use, that of fashioning it into middle soles to boots and shoes. The invention, according to the *American Manufacturer*, consists of a sheet of mica imbedded in thin coatings of cement, and placed in the boot or shoe under and adjacent to the insole, the upper leather of the shoe lapping over its edges, or next under the filling, or between the filling and the outer or bottom sole, and covering the upper space from the toe to the instep.

DR. SIEMENS' GAS AND COAL FIRE GRATE.

The growing obscurity which distinguishes the winter atmosphere of London has disposed men to consider whether it is an indispensable evil connected with the use of coal in great centers of population, or whether means can be found of providing the warmth and comfort which the copious use of mineral fuel affords us without having to pay the penalty of dispensing with the solar ray, of finding ourselves and everything we touch covered with soot, and of occasionally having, even at midday, to grope our way with a feeling akin to suffocation.





a, Copper plate ¼ inch thick and 10 inches wide at back of grate; b, frill of copper 1/16 inch thick; c, iron dead plate riveted to plate a; d, angle plate with trap-door, e, for removing ashes; f, gas-pipe about ½ inch diameter with holes ¾ inch apart.

I am decidedly of opinion that the evil is one which not only admits of remedy, but that its cure would result from a closer attention to the principles of economy in the use of fuel.

Until within recent years wasteful expenditure was the rule both in the application of fuel to our large manufacturing operations and for domestic purposes, but great strides have been made within the last twenty years to improve our mode of burning fuel both under our steam boilers and in the metallurgical furnace. The regenerative gas furnace, which was the subject of Faraday's last discourse at the Royal Institution in 1862, has contributed its share to this result, combining as it does considerable economy with the entire absence of smoke from the chimney.

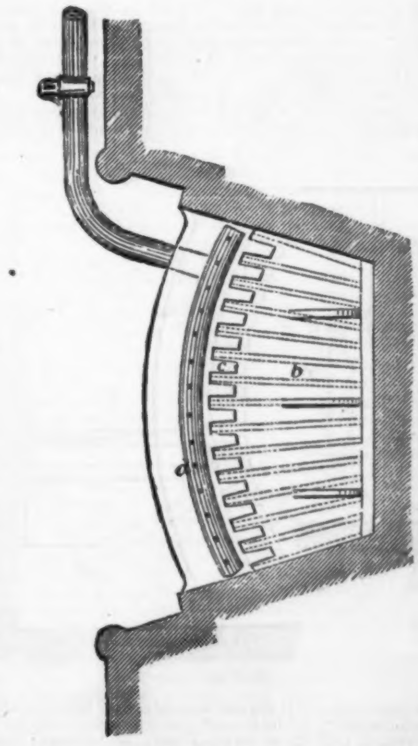
Since by the employment of gaseous fuel results such as these are realized, there seems no *à priori* reason why analogous results should not attend its application on a smaller scale, even down to the means of heating our apartments, which, although a small application in each individual instance, amounts, in the aggregate, to the largest of all the uses of mineral fuel.

Gas grates have been tried by individuals desiring progress, but I know several instances in which, on account of the great comparative expense incurred, and objections raised to the smell and dry heat, as it is called, in the room, the time-honored smoky but cheerful coal fires were reinstated.

A gas grate that was arranged in my billiard-room in the usual fashion, consisting of three air-gas-pipes with apertures distributed over the fire grate, and covered with pumice stone, presented certainly a cheerless appearance, and filled the room (notwithstanding a fair chimney draught) with fumes, rendering the benefit of the fire a doubtful one. These fumes could not have passed into the room from the upper surface of the pumice stone, owing to its proximity to the chimney; but a little consideration made me come to the conclusion that these gases really proceeded from the ash-pan into the room. The products of combustion set up by the gas flames ascend no doubt so long as they are intensely hot, but in giving off their heat to the inert pumice stone they rapidly cool, and being heavier than atmospheric air, descend through the grate between the lines of gas flames, and thus reach the apartment. Moreover the gas burnt towards the back of the fireplace takes scarcely any part in providing a red radiating surface in front of the grate, serving only to baffle the draught passing toward the chimney from the room.

The first condition to be realized in an efficient gas grate consists in suppressing all gas orifices except immediately behind the bottom front bar, and in substituting for the grate a solid dead plate. Instead of using inert matter such as pumice-stone, I consider it far more economical and efficacious to transfer the heat of the gas flames to gas coke or anthracite, which when once heated helps the gas to increase and maintain a sufficient temperature for radiation through its own slow combustion. The gas should not be mixed in the pipe with atmospheric air to produce a Bunsen flame, as is frequently done, because by using the unmixed gas a rich flame is set up between the pieces of coke near the front of the grate, producing to the eye an appearance similar to a well-ignited ordinary coal fire, and the hot carbonaceous matter through which it percolates insures its entire combustion before reaching the chimney. Heat will, however, gradually accumulate towards the back of the fire, notwithstanding the suppression of the grate bars, and in order to obtain the utmost economy this heat should be utilized to increase the temperature of the gas flames and of the coke in front of the grate.

To accomplish this I have constructed a grate according to the annexed sketch. The iron dead plate, c, is riveted to a stout copper plate, a, facing the back of the fire-grate, and extending five inches both upward and downward from the point of junction. The dead plate, c, stops short about an inch behind the bottom bar of the grate to make room for a half-inch gas-pipe, f, which is perforated with holes of about one-twentieth of an inch in diameter placed zigzag at distances of three-quarters of an inch along its upper surface. This pipe rests upon a lower plate, d, which is bent downward toward the back so as to provide a vertical and horizontal channel of about one inch in breadth between the two plates. A trap-door, e, held up by a spring, is provided



for the discharge of ashes falling into this channel. The vertical portion of this channel is occupied by a strip of sheet copper about four inches deep, bent in and out like a lady's frill and riveted to the copper back piece. Copper being an excellent conductor of heat, and this piece presenting (if not less than a quarter of an inch thick) a considerable sectional conductive area, transfers the heat from the back of the grate to the frill-work in the vertical channel. An air current is set up by this heat, which, in passing

along the horizontal channel, impinges on the line of gas flames and greatly increases their brilliancy. So great is the heat imparted to the air by this simple arrangement that a piece of lead of about half a pound in weight introduced through the trap-door into this channel melted in five minutes, proving a temperature to exist exceeding 619° F. or 326° C. The abstraction of heat from the back has moreover the advantage of retarding the combustion of the coke there while promoting it at the front of the grate.

The sketch represents a fireplace at my office, in a room of 7,200 cubic feet capacity facing the north. I always found it difficult during cold weather to keep this room at 60° F. with a coal fire, but it has been easily maintained at that temperature since the grate has been altered to the gas-coke grate just described.

This heating arrangement is not, however, essentially necessary; in several of the grates which I have altered for gas I have simply closed up the space below the bottom bar by means of a close-fitting ash-pan, and introduced the gaspipe behind the lower bar, an alteration which can be effected at very trifling expense, and presents the advantage of great cleanliness, the ash-pan being withdrawn only at intervals of several days for emptying. The appearance of the fire, however, is in that case much less brilliant than when the hot-air arrangement is added.

In order to test the question of economy I have passed the gas consumed in the grate through a Parkinson's ten light dry gas-meter supplied to me by the Woolwich, Plumstead, and Charlton Consumer's Gas Company; the coke used is also carefully weighed.

The result of one day's campaign of nine hours is a consumption of 62 cubic feet of gas and 22 lb. of coke (the coke remaining in the grate being in each case put to the debit of the following day). Taking the gas at the average London price of 3*s*. 6*d*. per 1,000 cubic feet and the coke at 18*s*. a ton, the account stands thus for nine hours:

62 cubic feet of gas at 3*s*. 6*d*. per thousand	2·604*d*.
22 lb. coke at 18*s*. a ton	2·121
Total	4·725

or at the rate of 0·524*d*. per hour. In its former condition as a coal grate the consumption exceeded generally two and a half large scuttles a day, weighing 19 lb. each, or 47 lb. of coal, which at 23*s*. a ton equals 5·7*d*. for nine hours, being 0·633*d*. per hour. This result shows that the coke gas fire, as here described, is not only a warmer but a cheaper fire than its predecessor, with the advantages in its favor that it is thoroughly smokeless, that it can be put off or on at any moment (which in most cases means considerable economy), that it is lit without the trouble of laying the fire, as it is called, and keeps alight without requiring to be stirred.

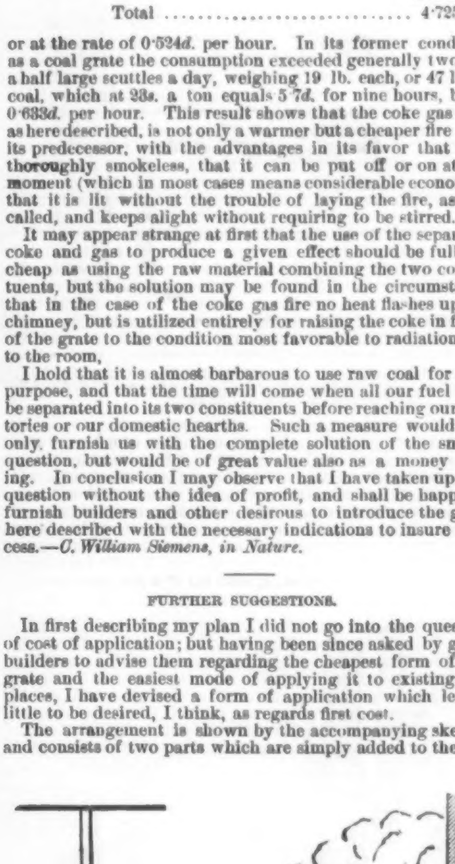
It may appear strange at first that the use of the separated coke and gas to produce a given effect should be fully as cheap as using the raw material combining the two constituents, but the solution may be found in the circumstance that in the case of the coke gas fire no heat flashes up the chimney, but is utilized entirely for raising the coke in front of the grate to the condition most favorable to radiation into the room.

I hold that it is almost barbarous to use raw coal for any purpose, and that the time will come when all our fuel will be separated into its two constituents before reaching our factories or our domestic hearths. Such a measure would not only furnish us with the complete solution of the smoke question, but would be of great value also as a money saving. In conclusion I may observe that I have taken up this question without the idea of profit, and shall be happy to furnish builders and other desirous to introduce the grate here described with the necessary indications to insure success.—*C. William Siemens, in Nature.*

FURTHER SUGGESTIONS.

In first describing my plan I did not go into the question of cost of application; but having been since asked by grate builders to advise them regarding the cheapest form of my grate and the easiest mode of applying it to existing fireplaces, I have devised a form of application which leaves little to be desired, I think, as regards first cost.

The arrangement is shown by the accompanying sketch, and consists of two parts which are simply added to the ex-



isting grate, viz.: (1) the gas-pipe, (*d*), with holes of about 1/16 inch diameter, 1·5 inch apart along the upper side, inclining inward, and (2) an angular plate, (*a*), of either cast or wrought iron, with projecting ribs, (*b*), extending from front to back on its under-side, either cast or riveted to the same, presenting a considerable area, and serving the double purpose of supporting the additional part on the existing grate and of providing the heating-surface produced by the copper plate and frill work in my first arrangement. In using iron instead of copper it is necessary, however, to increase the thickness of these plates and ribs in the inverse ratio of the conductivity of the two metals, or as regards the back plate, from 1/4 inch to 5/8 inch.

The arrangement will be rendered more perfect by the use of the bent plate fastened to the lower grate bar, which directs the incoming air upon the heating-surfaces.

The front edge of the horizontal plate has vandyked openings, (*c*), so as to form a narrow grating, through which the small quantity of ashes that will be produced by combustion of the coke and anthracite in the front part of the grate discharge themselves down the incline toward the back of the hearth, where an open ash-pan may be placed for their reception.

In adapting the arrangement to new grates, the horizontal grating had better be dispensed with, and the casting with its lower ribs extended downward, so as to find its fixed support between the back of the fireplace and the inclined deflector plate.

Mr. Fletcher speaks of the large amount of ashes that would be produced, but this amount can surely not be as great as in the case of a coal fire, seeing that the consumption of solid fuel is reduced to less than one-half, of which nearly one-half is anthracite, a fuel remarkably free from ashes. Neither do I participate in Mr. Fletcher's fear regarding opposition on the part of housemaids, except it be from an apprehension on their part that, with Othello's and the chimney-sweeps', their "occupation be gone."

The tendency of grate-builders of the present day, and also of your correspondents, appears to be to look for economy to brick-linings which no doubt have the effect of producing hot radiating surfaces. I maintain, however, that such radiation is obtained at too great a cost of fuel, and that superior economical results will, on the contrary, be attained by abstracting the heat from the back of the fire, and concentrating it upon the purely carbonaceous material in front of the same.

To illustrate my reasoning I may here refer to an experiment which can easily be made of throwing a shovelful of bituminous coal into a steel melting furnace; the result is an instantaneous dispersion of the coal, accompanied with a powerful refrigerative action on the furnace. In constructing gas producers I take advantage of hot walls to turn solid into gaseous fuel, and a fireplace with hot brick bottom and sides is very much in the condition of a good gas producer, giving out radiant heat no doubt, but combined with rapid distillation of combustible gases into the chimney. This action is made apparent in placing on the fuel towards the back of such a grate when in full glow a piece of wood, which will be seen to dwindle away rapidly without giving rise to flame, the atmosphere immediately over the glowing fuel being essentially a reducing one.

In my grate the heat, on the contrary, is confined to the coke immediately behind the bars, in contact with the heating gas flames and with the air of the room flowing in toward the chimney, whereas the coke at the back of the grate remains comparatively cool and unconsumed throughout the day. The cold furnace back also means a cold chimney, and it is rather remarkable to observe that in the case of the application at my office, a thermometer held high up into the chimney showed a temperature of only 130° F., while the front of the grate was in a high state of incandescence. These, I maintain, are conditions most favorable to economy combined with entire absence of smoke or deleterious gases.—*C. William Siemens.*

PROGRESS OF THE MINING OPERATIONS AT FLOOD ROCK, HELL GATE.

THOUSANDS of passengers by the Sound steamers gaze every day with considerable curiosity upon a little island that has sprung into existence in the middle of the East River, at the upper part of New York City, opposite Astoria. Rough wooden buildings with hoisting apparatus and smoke-stacks cover the surface, and little clouds of steam puffing up here and there give the whole the aspect of an extensive manufactory. The spectator, who from the steamer's deck marks the white caps breaking round this island, little thinks that deep down under his vessel's keel there is a miniature city whose streets are filled with life and activity. Yet it is there. The island is built upon the crown of Flood Rock, the most dangerous obstruction of Hell Gate, and deep down in its bowels the workmen of General Newton are digging and drilling night and day, oblivious of the tides that flow and the vessels that come and go above their heads. Already they have dug out of the solid rock more than two miles of streets, four or five feet wide and seven feet high. The rock to be removed has a surface area of nearly nine acres, and this is intended to be finally demolished by a single blast. Already 783,000 cubic feet of stone have been taken out, making a great cavern, larger than was the famous one at Hallett's Reef when it was blown up. That great blast was made with 50,000 pounds of the highest explosives. The blowing up of Flood Rock will require more than 200,000 pounds, and people who were timid as to the results of the former will probably leave the State when the new blast is to be made. Three "shifts," averaging fifty men each, carry the work through the twenty-four hours without interruption, day and night being alike in that hollow deep.

A REPORTORIAL VISIT.

Through the courtesy of Captain Mercur, the assistant of General Newton, a *Herald* reporter was recently permitted to visit the spot. Access to the mine was gained through a dark and narrow shaft sunk perpendicularly into the crown of the rock. At a depth of sixty feet the floor of the excavation was reached. Three yards from the shaft in any direction the darkness was Cimmerian. In what seemed the vast distances the tiny lamps on the miners' hats could be seen flickering, the wearers being invisible in the gloom. Pushing blindly after the superintendent of the miners, Mr. Bernard Boyle, who acted as guide, the visitor plashed through pools of water and stumbled over fragments of stone that covered the floor of the main heading. Water from the river above constantly trickled through the twelve feet of rock left as a roof; and fell with a noise like that of falling rain. This incessant pattering, mingled with the sharp noise of drills at work somewhere in the gloom, produced a mournful sound that seemed singularly appropriate to the place. Pausing under a spot where the water fell in considerable volume the guide holds up his smoking lamp to examine the fissure. The strata of the rock show a slight seam, through which the weight of the river (twenty-six feet deep) presses the water with great force. This will need careful handling, as the bringing down of even a small section of the roof here would let in the river and drown the miners. The visitor is made nervous by the reckless way in which the men seem to drill holes in the ceiling of the tunnel. How can they tell that they are not within a few inches of the cruel river foaming over their heads? A few yards further on a corner is turned, and there, near the extreme end of a heading, stands a surveyor with his instrument taking levels and indicating the direction to be pursued. The contour of the top of the rock has been accurately ascertained by sounding and diving through the river, and the carefully drawn map in the superintendent's office shows every indentation, so that the spots where the roof may be thin are known, and the men blast away without fear of bringing down destruction upon their heads.

A ROCKY MAZE.

There are ten tunnels running parallel with the current of the river, and each of these at present is 600 feet long. These are crossed by thirteen shorter ones, the whole forming a sort of maze in which nothing could be easier than to get lost. Indeed the workmen themselves occasionally do this. Only a sprinkling of these men are old miners, the greater number being young fellows from New York or Long Island. Many of these, however, had some experience in the Hallett's Reef excavation, and they make good workmen, given an old miner here and there to note the character of the stone and guard against the dangers of its crumbling down. As the eyes become accustomed to the place a thick, black rubber hose is noticed stretching along the floor of the narrow passages and emitting occasionally a hissing sound as if it were some great serpent having its home in this gloomy cavern. Through this the steam is conveyed which drives the drills. There are ten of these machines, and each of them drills in the twenty-four hours about twenty-five holes, four feet deep and two inches in diameter. Thus 250 holes are bored every day. The blasting is done only in the evening, when the holes are charged and fired immediately, this part of the work occupying three or four hours. Frequently the concussions put out the miners' lamps, and residents of the river banks are treated to an occasional tremor. Getting on in this way about five hundred feet of tunnel is dug out per month. The stone is removed in cars run on tracks laid down as the tunnels are driven, hoisted up through the shaft, whence, by an ingenious automatic contrivance, it is dumped into scows.

HOW THE STONE IS DISPOSED OF.

The stone is disposed of in an odd way. Just north of Blackwell's Island and between that and Flood Rock is an immense hole in the river bottom, and into this the *débris* is deposited almost within a stone's throw of the place whence it was taken. When this dumping was begun the hole was 126 feet deep, but the bottom seems to give way under pressure, for notwithstanding the immense quantity of rock thrown into it a sounding line 120 feet long failed to reach bottom. The only "parlous adventure" encountered by the reporter during the underground trip was in connection with the moving of this broken stone along the tunnels. Carrying his tiny oil lamp rather carelessly he backed up against something rather soft in the darkness, and stretching out his hand, it touched the hind quarter of a lively mule! Three of these animals are used to draw the car loads of stone. They were lowered into the mine more than a year ago, and have never since been in the sunlight, but they seem to thrive, and the drivers say their kicking powers are undiminished. A good, dry stable has been built for them in one of the main shafts, and they are well fed and cared for. Although the floors of the galleries are running streams, the roof rains and the walls are wet with ooze from the river bed, the air is not bad. Openings have been made for the purpose of producing draughts, and an immense fan is kept in motion at the main shaft, blowing out the air. From this opening, when the fan is in motion, a cloud of smoke constantly rises. It comes from the lamps of the miners. After an hour spent below the nostrils become filled with lampblack from this source.

ON THE ROCK.

On the surface of the rock is a blacksmith's shop, in which the drills and picks are forged, a shop where the machinery is repaired, and a spacious boiler house, where the steam is generated which works the drills and runs the pumps that restore the water to the river as fast as it leaks in through the roof. When the work was begun the surface of the rock was submerged at flood tide, and it was necessary to build a coffer dam in order to sink the shaft. This accomplished, the stone as fast as blasted was deposited around the shaft, and thus was built up the surface on which the present buildings stand. It is impossible at present to say when the tunneling will be finished and the preparations made for the great blast. Probably the summer of 1883 will witness the completion of the work. It is General Newton's intention to fire the entire blast simultaneously, as he did at Hallett's Reef, and the tunnel will be flooded before the discharge, as in the former case. Notwithstanding the incredible quantity of explosives to be used he expects that the water will act as a cushion and prevent any damaging concussion.

MACHINE FOR MAKING VELVET SHEEPSKINS.

IN addition to having introduced an entirely new process for making velvet from sheep skins, M. Puech, of Mazamet, France, has also invented improvements in the old method of preparing these articles for use as fur linings. The old style of working is primitive, requires much time, and is not always attended with success. According to this invention the process comprises several operations, consisting essentially in dipping the skins in a bath of hot water, to which is added soap, soda, salt, and so forth, for scouring them; in pressing them sufficiently to extract the yolk and impurities; in beating them successively on each side, and in simultaneously washing them in cold or tepid water; in steeping them for a more or less length of time in a tepid bath, to which is or is not added a bleaching substance, and capable, if desired, of forming a dyeing bath; in drying them; in beating them forcibly, and in covering them with tanning matter, and in finally drying them. This rapid and economical method admits of preparing the most difficult skins for tanning in the space of about two hours, and the wool acquires such a cleanliness that no further cleaning is necessary to impart to it all the beauties and qualities of which its nature is susceptible. The following is an explicit description of the several operations comprising the complete process of this method:

1. A trough of hot water is prepared and maintained at 40° to 45°, with a matter added for scouring the wool, such as soap, soda crystal, or soda salt; the skins are steeped therein for about a quarter of an hour, and the bath is preserved till it indicates 5° by the saline detecter. The object of preserving the bath is to economize the scouring matters, as the yolk of the skins which is liberated ameliorates the bath in proportion as the skins are steeped therein. For instance, a bath containing 1,325 gallons of water will scour from 1,200 to 1,500 skins.

2. The skins are passed to a pressing roller for extracting

the yolk, dirty wool, and foreign matters. This operation lasts a second, and at the same time the yolk is conducted to the scouring bath above mentioned.

3. Immediately after, and as quickly as possible while the skins are hot, they are submitted to a beating machine of some kind, Blaquière de Bedarieux, for instance, or some analogous machine. This operation is intended to remove the dirty water, thistles, burrs, and straws; in a word, to purify, scour, cleanse, and thoroughly wash the skins, care being taken to allow an abundance of cold or tepid water to fall between it and the drum.

In the accompanying drawings of a Blaquière beater (Fig. 1) the skin, P, is beaten between the cylinder, A, supplied with projections, and another drum, b, furnished with paddles or pallets. During this mechanical operation a bath, c, pours abundant water between the drum, b, and the cloth, d, supporting the skin.

one another by means of the separators, s,s, and the beater or agitator, t. These seven operations essentially constitute the novelty of the invention.

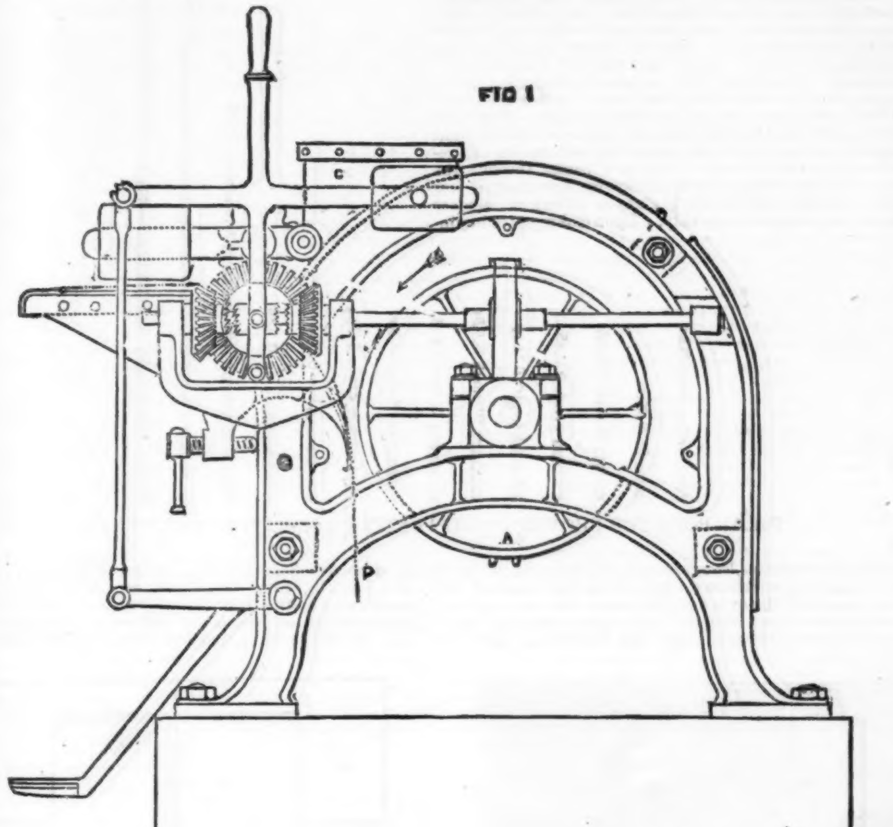
8. A tanning substance composed *ad hoc* is immediately, with a brush or mechanically, passed over the flesh side, and the skins are thus left for twenty-four hours. If they are difficult to prepare the tanning matter is applied a second time.

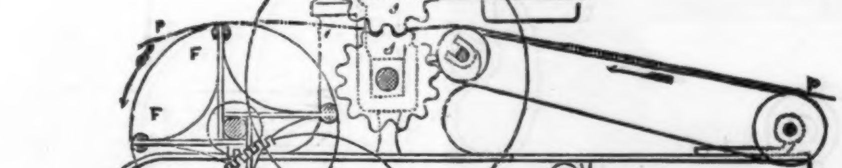
9. They are now dried in the open air or by stove, and after having admitted on the dry skin a little tepid water to soften the leather it is delivered to the workman to scrape the leather till it is quite clean, either by hand or mechanically. If the skin is meant for use as a rug the wool is combed, and in this state the skin is ready for commerce, while if it is a short wool skin intended for clothing the combing is not necessary.

10. If the skins are to be bleached it is merely necessary to throw a little water on the wool side so as to damp the filaments, and the skins are left forty-eight hours in a sulphur vapor chamber for bleaching. Bleaching may be effected by other means; for example, by putting the skins in a cold bath (after the fourth operation) added to which is a bleaching substance, leaving them in it six hours, and continuing the subsequent operations as already described.

Finally, if the skins are to be dyed, to the bath of the fifth operation is added the desired color, and the other stages follow as described.—*Universal Engineer.*

FIG 1





MACHINE FOR MAKING VELVET SHEEP SKINS.

4. The skins are returned to the same machine for beating them on the flesh side, so as to remove the superfluous flesh; scrape and render the skins supple, clean them and remove from the edges all the imperfections which have escaped beating on the wool side. This second beating is effected like the first, in a minute.

5. The skins are again steeped in a bath heated from 35° to 40° for about thirty minutes. This operation perfectly opens the pores of the skins and prepares them for efficaciously receiving the tanning matter.

6. The skins are immediately passed under a pressing roller to dry them.

7. The skins being still damp are beaten forcibly on the wool side by means of rods, or are submitted to a velveting machine, such as represented by Fig. 2. The object is to raise the staples to inflate them, and separate them from

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THE valve of a hundred horse power engine should have a lead of probably about three-sixteenths of an inch. There is no rule; it depends upon pressure of steam, size and form of opening, and velocity of the engine.

THE POLYTECHNIC ASSOCIATION.

THE Polytechnic Association of the American Institute held its regular weekly meeting on the evening of the 6th of January, Thomas D. Stetson presiding.

A newspaper scrap was read announcing a newly-discovered process for the preservation of dead bodies, originated in Germany and patented there; but the patentee had been induced to abandon his patent and make it public property for the benefit of the world. A liquid was made by which the bodies were embalmed by being saturated and impregnated with it. Three thousand parts water, one hundred alum, sixty potash, twenty-five common salt, twelve saltpeter, and ten arsenic acid was made the first composition. Then to ten parts of this, four parts of glycerine and one of methylene were added. Bodies preserved by this were alleged to fully retain their form, color, and flexibility for years.

In the discussion it was doubted that the color would be preserved. There were compounds which would preserve human bodies very perfectly if they could be thoroughly impregnated before decay had commenced. A company in this city, the New York Sanitary Company, furnish a fluid and instruments for applying it, by which the interiors are very thoroughly impregnated before decay commences. Then a moderate treatment on the surface with the same or other preserving fluid insures the preservation of the body in a high degree of perfection for a long period. The body of the well-known actor, Mr. Porter, who was killed in Texas, was preserved by the aid of this process, and brought to this city and seen by his friends at the funeral fourteen days after death.

An account was read from *Iron* of a process of printing many colors at one operation, alleged to be in successful operation in France. A solid block was formed in mosaic of different colors, using blocks of pigments, all capable of being acted on by a chemical or combination of chemicals. A thick mass of this is mounted in the press, planed off smooth, and then wetted rapidly on the surface with the proper fluid, and the paper or other material placed thereon and pressed. A clear impression is thus obtained in all the colors, and in the case of textile fabrics the color goes completely through their substance. After exposure for a brief period to heat, to drive off the fumes of the chemicals employed, the work is finished.

Mr. MacDonald said he had assisted in trying similar experiments in this country. In those experiments glycerine was used, and the printed impressions had the peculiarities due to the presence of glycerine that they remained damp. The process, so far as he had known it, had been always a failure. The sharpness of the impressions would be satisfactory to some, but not to a good printer, and the character of the work generally was inferior.

Mr. Blanchard developed on the blackboard a mode original with him for computing the strains on the different parts of bridges. Eddy, Stoney, Dubois and others had analyzed with immense fineness, but their methods were too complicated. It could be done much more simply. The relative strains on every part were ascertained by geometrical figures. The operation was rapid and sure. It was an improvement on the ordinary diagram for the decomposition of forces. The vertical strains were represented by horizontal rather than vertical lines.

The discussion following developed singular anomalies in the failure of bridges. The Montmorenci Bridge near Quebec, after bearing immense loads for a long period, fell suddenly with nothing on it. It appeared that the fracture of wrought iron under continued strain was a gradual process, the catastrophe occurring as the result of a slow failure which had been initiated much earlier. Mr. Hudson referred to the failure of the chain bridge across the Merrimac River in 1826 after a heavy snow storm.

The President referred to the great perfection which theoretical and practical science has been brought in modern bridge building, as exemplified in the costly East River Bridge, which, we hope, will prove, as it promises, a masterpiece of the art. He also mentioned the two famous bridges near each other at North Bangor in Wales—one, a suspension bridge, completed in 1825, before the superiority of small wire cables for such purposes had been established. Wires were immensely easier to stretch across one at a time, and were found much superior in strength for a given weight when completed. That bridge was built with what are sometimes termed pitch chains—bars of iron laid three or four abreast and knuckled together by transverse pins through their ends. It continues to be used for general carriage traffic. Near it is the famous tubular bridge engineered by Stevenson & Fairbairn, which carries the railway trains between Anglesea and the main island of Great Britain. Shipping moves under both bridges through the Menai Straits.

An extract read from the editorial correspondence of the Philadelphia *Press* of last summer developed a long conversation with one of the leading silk manufacturers of Lyons, in which he sadly admitted the competition, dangerous to their industry, of Americans in the silk manufacture. In the discussion which followed it was stated that there are now about two hundred separate manufactories in America for woven and sewing silks. American manufacturers load their silks with less foreign matter, and make an article which is superior in wear but not as brilliant in gloss. Paterson and other points manufacture ribbons with eminent success. Hartford manufactures dress goods of somber colors superior to any in the world. We import about 7,500 tons per annum of raw silk, and manufacture it here. The raw silk made in this country is slight. Wages are too high. It requires cheap labor, as in Italy, China, etc. Machinery has not yet succeeded in reeling cocoons.

But immense areas of our country have mild winters, and are every way favorable for the silk worm. We can raise cocoons and ship them abroad to be reeled and returned. We are producing cocoons largely in North Carolina and California.

A paper full of thought and facts, read by Professor De Volsen Wood, opened the main subject of the evening, the "Relations of Machinery and Labor." He held that the present era of machinery has induced great revolutions in labor and laborers, but the general effect is eminently beneficial.

The farmers of Ohio opposed railroads in the belief that they would diminish the demand for horses and oats, until it was shown that the introduction of railroads resulted in an increased price for both in every instance. A machine which made one man do the work of ten, at first sight appeared to dispense with the labors of nine, but labor is more constantly in demand and better paid than before machinery was introduced. A farmer's wife in the West told him that their reaping machine, by reducing the number of men to feed during harvest, had lightened her

work more than her sewing machine. The increased production of the earth must result in greater wealth to the world. Fifty thousand reaping machines involve, in the first instance, a quickened demand for metal, wood, skilled labor, and means of transportation. It calls for buildings, clerks, and agents. The wealth it produces calls for buildings, stock, carpets, music, books, and works of art. Thus, apparently unconnected branches of business are benefited by the reaping machine.

The discussion following questioned one proposition: It was doubted whether the reign of machinery tended to narrow the faculties by confining a man to one branch of labor. Formerly a long apprenticeship trained the faculties to the production of a wrought nail or a pin head, and there stopped. The apprentice system is gone. There is danger from its absence, but so far, in America at least, the intelligence developed by the schools, general and technical, have successfully taken its place, and all are mobile. Our great manufactories, with their hum of machinery, are schools to every young man, and warn him that he should be ready for emergencies. We have no indolent rich, no idle class except the tramps, and they are disappearing. All can, and do, work with head or hands, and nearly all can change successfully from one business to another with only three weeks of special training.

PHYSICS WITHOUT APPARATUS.

THE following are a few miscellaneous experiments which may be easily performed to illustrate various subjects in physics:

To show the production of sound by vibrations in sonorous bodies, the easily-constructed musical instrument known as the *harmonicon* may be employed. This consists of a number of glass goblets placed on the bottom of a box which acts as a sounding board. The goblets are attuned to each other so as to form a harmonical scale, by filling them to different heights with water. The glasses are made to vibrate by touching the edges with the wet finger, and their tunes may be thus prolonged and made to swell or diminish like those of the violin. The same effect in playing a tune may be produced by striking the glasses with a rod (Fig. 1), but the sounds are not so agreeable as those obtained by the wetted finger. This simple contrivance, invented by Franklin, affords music which for sweetness, delicacy, and smoothness is hardly surpassed by that of any other instrument. The common Jew's-harp affords another simple illustration of the same acoustical phenomenon. When the tongue of this little instrument is struck its vibrations can be distinctly *seen*. The different sounds which it emits when in use depend upon the vibration of the currents of air blown across its tongue by the player, and upon the relative position of the lips and instrument. An experiment for showing the production of musical sound by flame may be performed in a very simple manner, and has long been known by the name of the *chemical harmonicon:* Take a long glass tube tapering off nearly to a point at its upper end, and, having placed it over an ordinary gas jet, turn on the gas and light it as it issues from the pointed end of the tube. When a glass tube, open at both ends, is held so as to surround the flame, a musical tone is heard, which varies with the dimensions of the tube, and often attains considerable power. The singing of the flame is due to the vibration of the air and products of combustion within the tube.

FIG. 1.—EXPERIMENT WITH THE HARMONICON.

To show that actual sources of light are not mere luminous points, but have finite dimensions, the following interesting experiment illustrating the phenomena of the umbra and penumbra may be tried. Draw on a piece of cardboard any object (a human face, for example), and, having put in the proper shades, cut out with a sharp pen-knife all those parts that are to appear light. The model in Fig. 2 will explain how this is to be done. Now, by interposing this card between a strong light and the wall of a room or a screen, we will obtain the effect shown in Fig. 3, provided the card is held close to the screen. By gradually drawing it toward the light, however, we will obtain the effect shown in Fig. 4, a more artistic appearance, due to the penumbra. The atmospheric phenomenon caused by refraction and total reflection of light, and known as the *mirage*, may be beautifully imitated by arranging in a vessel with glass sides (say a *very* small aquarium) three clear liquids, one above another, such that the middle liquid, while intermediate in density, has the highest density of refraction. For the lowest liquid a saturated and filtered solution of alum may be used, pure water for the highest, and clear whisky, with white sugar dissolved in it, for the intermediate liquid. The alum solution should be introduced first, then the water, and lastly the sugared whisky. The latter should be introduced carefully in sufficient quantity to form a layer about a quarter of an inch thick. With this simple apparatus, say about six inches square, very distinct triple images (the middle one inverted) may be obtained of all the objects in a landscape. "Newton's rings," which are due to the mutual *interference* of *light* reflected from the two surfaces of a thin film, may be shown by letting fall a drop of oil on the surface of clear water, when it spreads out into a thin film and exhibits golden fringes. The halos which occasionally surround the sun and moon when light fleecy clouds pass over them, and which are due to the refraction and interference of light as it passes through the latter, may be shown experimentally by spreading a few drops of a saturated solution of alum on a piece of window glass so as to crystallize quickly. Upon looking at a luminous body through this layer of crystals (which are so small as to be scarcely visible to the eye), with the uncoated side of the glass next the eye, *three fine halos* will be perceived encircling the source of light. The phenomenon of phosphorescence may be very simply and beautifully shown by rubbing together two pieces of lump sugar, or breaking a lump in the dark.

A curious experiment, showing atmospheric pressure by currents of air, may be performed as follows: Cut out two circular disks of card-paper about two inches in diameter, and insert a quill or other small tube in the center of one of them. Place the upper disk with its tube about a quarter of an inch above the lower disk. By blowing through the tube the lower disk will unexpectedly leap up and adhere to the upper one; and the harder the blowing the firmer it will stick. If the apparatus be inverted, the card cannot be blown off. The reason of this is, that the blowing drives the air out from between the disks and diminishes the pressure of the air on their *inner* surfaces; thus allowing them to be forced together by the balance of atmospheric pressure *without*. The following curious experiment appears to belong to the same category as the one last-mentioned, and to be explainable in the same way: To the base of a bottle-cork fix three large pins so as to form a sort of tripod. Into the upper end of the cork insert a fine knitting needle, and on the top of the latter balance a sheet of paper, as shown at Fig. 5, at A B. We will thus have two surfaces of paper capable of revolving about their axis at the slightest breath of air. Now, if one of these surfaces, A, for instance, be fanned with a stiff piece of cardboard, it will, instead of being repelled (as one might suppose), be attracted. The reason of this is that a slight vacuum is produced in front of the card, and the pressure of the atmosphere on the opposite surface thrusts it in the direction of the extemporized cardboard fan.

FIG. 2.—CARD CUT TO SHOW UMBRA AND PENUMBRA.

FIG. 3.—UMBRA PROJECTED BY THE CARD.

FIG. 4.—PENUMBRA PROJECTED BY THE CARD.

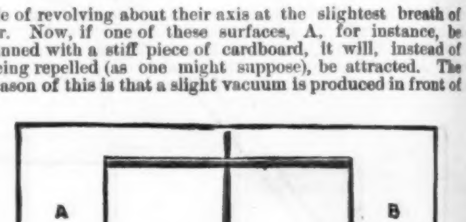

FIG. 5.—ROTATION OF PAPER BY ATMOSPHERIC PRESSURE.

Bodies with the same bulk or size do not always possess the same quantity of matter. The proportion of matter to the bulk is called *density*. To give an accurate notion of the density of solids (metals, for example), a cylindrical broom-handle may be cut into sections, having the proportions shown in Fig. 6. We will thus have a collection of cylindrical rods representative of the volumes of the different common metals proportionate to their densities—that is, having the same weight. These rods might be painted so as to imitate the colors of the metals which they represent—platinum, gray; copper, red; gold, yellow; iron, black, etc. By reference to the figure it will be seen that the sodium rod is more than twenty-one times longer than that of platinum; but each, although of a different size or volume, possesses the same weight. The rods here figured are in length about one-tenth that which they should really have in wood for a public course of lectures or a demonstration before a class.

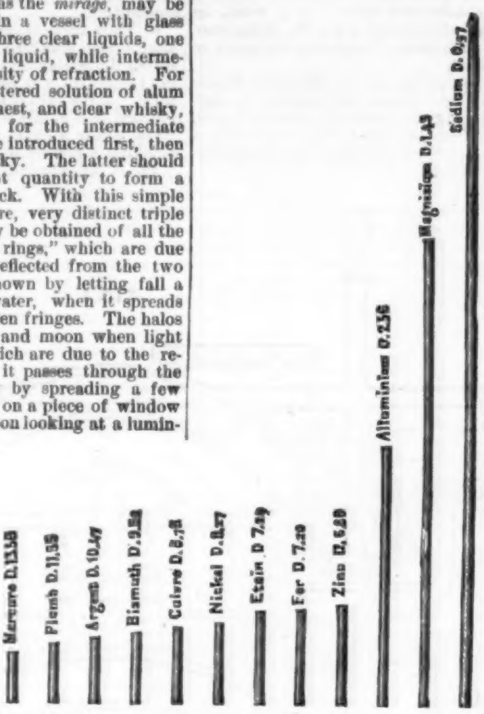

FIG. 6.—RODS FOR SHOWING COMPARATIVE DENSITY OF THE METALS.

STEEL PAINT.

A NEW invention has just been introduced into the Cleveland district, viz., the manufacture of paint from steel scale for the protection of iron and steel from corrosion in any position and in any climate. Messrs. Henry Porter and John Thomas have established a factory for this industry at Bowesfield, England. They obtain from the steelworks at Eston and elsewhere the scale that falls from the steel as it is passing through the rolls, and this, by their special machinery, they grind until it becomes as free from grit as flour, and then it is intermixed with boiling oil and coloring matter. Thus we have steel structures painted with steel. The paint is of two kinds—the anti-corrosive paint, for use above water to prevent structures from rusting, and the

anti-fouling paint for use under water, to prevent animal and vegetable life from attaching themselves to ships' bottoms and other ironwork. The inventors say that if painted with two coats of the composition, a vessel may go to India or Australia and return with a clean bottom, for barnacles and grasses cannot live in the vicinity of the paint. So far as the anti-corrosive paint is concerned, it will in the long run be cheaper than gas-tar for covering blast furnaces, and it will certainly more effectually prevent rust, and form an excellent protection to the metallic surface. The invention, which has been applied by Messrs. Bolckow, Vaughan & Co., and other firms, affords another illustration of the fact that nothing need be allowed to waste. Steel scale was not altogether wasted before, but it now becomes a valuable article of commerce.

ON THE HISTORY OF THE ARTIFICIAL PREPARATION OF INDIGO.

By CARL SCHORLEMMER, F.R.S.*

ONE of the most brilliant discoveries which lately has been made is that of the synthesis of indigo, the Indian color which is mentioned by Dioskorides and Pliny, as well as by the Arabians. It was, however, only after the discovery of the sea passage to India that it became generally known in Europe; but its use as a dye was greatly retarded by the opposition it met with from the large vested interests of the cultivators of woad, *Isatis tinctoria*, the European indigo plant. The English, French, and several German governments were induced by the growers of woad to promulgate severe enactments against it. Thus Henry IV. of France issued an edict condemning to death any one who used that pernicious drug called "Devil's Food." The employment of woad was, however, gradually superseded by that of Indigo; and as soon as organic chemistry had advanced far enough, chemists began to examine this important coloring matter, which was first obtained in the pure state by O'Brien, who states in his treatise "On Calico Printing," 1789, that on heating indigo the coloring matter volatilizes, forming a purple vapor, which condenses as a blue powder, while the impurities of the commercial product are left behind. Indigo-blue, or indigotin, as the pure compound is called, was afterwards analyzed by several chemists, who found that its most simple formula is C_8H_5NO, which was subsequently doubled for several reasons.

The literature of the chemistry of indigo is very large. Of the numerous researches I can here mention only those bearing directly on my subject.

In 1840, Fritzsche found that on distilling indigo with potash a basic oil is produced, which be called *Aniline*, $C_6H_5.NH_2$, from anil, "by which name the Portuguese introduced indigo first into Europe. The word is Arabic, and means simply the blue." In the following year be obtained, by boiling indigo with caustic soda solution and manganese peroxide, a compound which be called anthranilic acid, and which is now known as *orthamidobenzoic acid*, $C_6H_4(NH_2)CO_2H$. He also observed that by heat it is resolved into aniline and carbon dioxide.

At about the same time Erdmann and Laurent independently studied the action of oxidizing agents on indigo, and obtained *isatin*, $C_8H_5NO_2$, which is not a coloring matter. The further examination of this body led to most interesting results, but as those are not directly connected with the subject of this paper I cannot discuss them here. We must, therefore, proceed at once to 1865, when Baeyer and Knop found that by acting on isatin in an alkaline solution with hydrogen in the nascent state it is converted into a yellow crystalline body, which they called *dioxindol*, $C_8H_7NO_2$. This is easily further reduced in an acid solution to *oxindol*, C_8H_7NO, which forms colorless needles, and on its vapor being passed over red-hot zinc-dust it loses its oxygen, *indol*, C_8H_7N, being formed, which is also a colorless crystalline compound, and a most interesting body, inasmuch as it is also formed, as Nencki and Kühne have shown, in pancreatic digestion, and is contained in the fæces.

In 1869 Baeyer and Emmerling obtained indol from cinnamic acid, which occurs in several plants, and can be obtained artificially from coal tar, as I shall show further on. By the action of nitric acid it yields two isomeric nitro-compounds. One of them, called ortho-nitro-cinnamic acid, loses, when heated with caustic potash and iron filings, carbon dioxide and oxygen, and indol is formed, $C_6H_4(NO_2)CO_2H=C_8H_7N+O_2+CO_2$.

The same chemists discovered (1870) a method by which isatin can again be reduced to indigo-blue. By heating it with a mixture of phosphorus trichloride, acetyl chloride, and phosphorus to 70° to 80°, they obtained a green liquid which, when poured into water, deposited, on standing exposed to the air, a blue powder containing indigotin. At the same time a purple coloring matter was formed, which they called indigo purpurin.

It has been known for some time that urine, on standing, sometimes deposits indigo blue. Jaffé, in 1870, found that he could produce it by the subcutaneous injection of indol; and Nencki, who confirmed this observation in 1875, was able to convert indol into indigotin by the action of ozonized air. But the yield is only very small, as the coloring matter readily undergoes further oxidation.

However, the synthesis of indigo was thus completed, because indol can be built up from its elements; but chemists were not satisfied with it, the method being neither a practical one nor giving any clew as to the chemical constitution of indigo.

In the next year Baeyer and Caro found a very simple and elegant method for preparing indol; they obtained it by passing the vapor of ethyl-aniline through a red-hot tube:

$$C_6H_5-N\left\langle\begin{array}{l}H\\ CH_2-CH_3\end{array}\right.=C_6H_4\left\langle\begin{array}{l}CH_2\\ N\end{array}\right\rangle CH+2H_2.$$

Baeyer succeeded, in 1878, in obtaining oxindol from phenylacetic acid, $C_6H_5.CH_2CO_2H$, which can be prepared synthetically by different methods, and may be easily obtained from toluol. By treating the acid with nitric acid it is converted into the ortho-nitro compound, which is easily reduced to the corresponding amido-acid. But this, like several other ortho compounds, readily loses water and yields oxindol:

$$CH_4\left\langle\begin{array}{l}CH_2.CO.OH\\ NH_2\end{array}\right.=C_6H_4\left\langle\begin{array}{l}CH_2\\ NH\end{array}\right\rangle CO+H_2O.$$

This compound, as Baeyer and Knop had already found, is converted by the action of nitrous acid into nitrosoxindol. On treating this with nascent hydrogen it is transformed into amidoxindol, and this yields on oxidation isatin, the constitution of these bodies being expressed by the following formulæ:

Nitrosoxindol.	Amidoxindol.	Isatin.
$\begin{array}{c}CH(NO)\\ C_6H_4<>CO\\ NH\end{array}$	$\begin{array}{c}CH(NH_2)\\ C_6H_4<>CO\\ NH\end{array}$	$\begin{array}{c}CO\\ C_6H_4<>CO.\\ NH\end{array}$

I have already stated that isatin can be reduced to indigo-blue. Baeyer endeavored now to find a more simple method for effecting this. By acting with phosphorus pentachloride on isatin he obtained a compound which he called isatin chloride, which nascent hydrogen converts into indigotin, $2C_8H_4ClNO+2H_2=C_{16}H_{10}N_2O_2+2HCl$.

As far back as 1869 Kekulé predicted isatin to possess the constitution which it has been proved to have by Baeyer's researches, and two of Kekulé's pupils, Claisen and Shadwell, discovered in 1879 a very simple synthetical method for preparing it. By acting with phosphorus chloride on ortho-nitro-benzoic acid, $C_6H_4(NO_2)CO_2H$, the chloride, $C_6H_4(NO_2)COCl$, is formed, which when heated with silver cyanide yields the nitrile, $C_6H_4(NO_2)COCN$. On heating the latter with a solution of caustic potash it is converted into ortho-nitro-phenyl-glyoxylic acid, $C_6H_4(NO_2)CO.CO_2H$, and this is converted by nascent hydrogen into the amido compound, which, like other ortho compounds, loses water and yields isatin.

I have now given you a sketch of the history of artificial indigo up to 1879, when I wrote: "The artificial production of indigo has so far merely a theoretical interest; whether the time will come when simplified methods will admit of its manufacture on a large scale remains to be seen. But even if not, the indigo-purpurin, which is always formed together with the blue, may become of importance as a coloring matter. This body, as Dr. Schunck has shown, is identical with his *indigorubin*, which always occurs, but in small quantity only, in indigo. Dr. Schunck has traced the formation of this beautiful purple color in *Polygonum tinctorium*, a plant used in China and Japan for the preparation of indigo. He has cultivated it for several years, and found that the young plants do not contain a trace of it. It can be only obtained from plants having attained an advanced stage of development. It dyes under the same conditions as indigotin does; but while the latter dyes a dull dark blue indigorubin dyes a fine purple shade. Dr. Schunck, who is an authority on these matters, is of opinion that if it could be obtained in quantity it would be a most valuable addition to the colors now in use."*

Since this has been written Baeyer has succeeded in finding a method which to all probability will soon be employed for the manufacture of indigo-blue on a large scale. The starting point is from cinnamic acid, which occurs in nature, being found in gum benzoin, styrax, balsam of Peru, and a few other aromatic bodies. These sources would be, however, far too expensive, and the quantity obtained therefrom much too small, to make use of them. Now, Bertagnini found, as early as 1856, that this acid may be obtained artificially by heating benzaldehyd, or oil of bitter almonds, with acetyl chloride:

$$C_6H_5.CHO+CH_3.COCl=C_6H_5.C_2H_2.CO_2H+HCl.$$

Since that time several processes have been found for obtaining oil of bitter almonds from toluol and from benzoic acid. The first point to be settled was, therefore, to ascertain which is the cheapest and best method for preparing this compound, as well as acetyl chloride, which is produced by the action of phosphorus chloride on acetic acid.

W. H. Perkin, F.R.S., has discovered another synthesis of cinnamic acid, which probably may also be of practical value. He obtained it by boiling benzaldehyd with acetic anhydride and sodium acetate.

By the action of nitric acid on cinnamic acid we obtain ortho-nitro-cinnamic acid, $C_6H_4(NO_2)C_2H_2CO_2H$, which readily combines with two atoms of bromine to form dibrom-nitro-phenyl-propionic acid. This compound, by the action of alkali, is transformed into ortho-nitro-phenyl-propiolic acid:

$$\begin{array}{l}C_6H_4(NO_2)C_2H_2Br_2.CO_2H+2NaOH\\ =C_6H_4(NO_2)C_2.CO_2H+2NaBr+2H_2O.\end{array}$$

The latter acid yields pure indigo when its alkaline solution is heated with a reducing agent, such as grape-sugar, indigotin being deposited in the crystalline state:

$$2C_9H_5NO_4+2H_2=C_{16}H_{10}N_2O_2+2CO_2+2H_2O.$$

Besides this method Baeyer has patented some others in which also cinnamic acid is used. These processes are now worked out by two of the greatest color works on the Continent.

How far the artificial production of indigo will be a commercial success remains to be seen. As far as I understand, it is at present only intended to manufacture nitro-phenyl-propiolic acid, which, when mixed with an alkali and grape-sugar, is printed on the cloth. By the action of steam a pure indigo-blue is produced, which would form a most valuable addition to the host of steam colors which are now so largely in use.

In conclusion I must mention another of Baeyer's discoveries which promises to be of practical value. We can easily replace in isatin one atom of hydrogen by bromine, the nitro group, amido group, etc. By subjecting these substituted isatins to the action of phosphorus chloride they are converted into chlorides, and these yield, by treatment with reducing agents, substituted indigos. These bodies are all colored, and their properties are very similar to those of indigo. It appears not improbable that some of them might find application in dyeing or printing, and be prepared, not from isatin, but from substituted cinnamic acids.

When, twelve years ago, the artificial madder colors were discovered, it was not believed that they could be produced in sufficient quantity nor cheap enough to compete successfully with the natural colors. To-day the cultivation of madder has almost ceased; whether this will happen in the case of indigo is a question which I think will soon be solved.

* Read before the Manchester Literary and Philosophical Society.

* "The Rise and Development of Organic Chemistry." Manchester: Cornish

EASY TEST FOR ARSENIC IN FABRICS.

IMMERSE the suspected paper in strong ammonia on a white plate or saucer; if the ammonia becomes blue, the presence of a salt of copper is proved; then drop a crystal of nitrate of silver into the blue liquid, and, if any arsenic be present, the crystal will become coated with yellow arseniate of silver, which will disappear on stirring.—*Practitioner.*

SILK DYEING.

By M. DE VINANT.

Light Yellow.

THE silk must not be washed, and a red shade is first given with annatto in a soap beck, not too strong. It is then washed and raised in the cold with sulphuric acid. The yellow shade is then given with picric acid, and the silk is then dried without washing.

For a heavier shade the process is the same, but turmeric is used instead of picric acid.

The solution of annatto is made by boiling together for half an hour equal weights of potash and annatto.

Scarlet.

Boil for half an hour 11 lb. ground cochineal; filter, and set the clear liquor at 4° Tw. Add to the beck about 24 fluid oz. tin solution, and dye. It requires twenty-four hours to produce the scarlet.

After dyeing the silks are left wrapped up for twelve hours, rinsed slightly, brightened with citric acid, and dried.

The solution of tin is made as follows:

Muriatic acid	4 lb.
Nitric acid........................	2 "
Feathered tin......................	1-5th lb.

Dissolve gradually in the course of a day.

Maroon.

Take the silk through a catechu beck, weight for weight, if a *good* yield is desired. If a smaller yield is wished, less catechu is taken.

Dye at a boil, lift, wring, and pass into a chrome beck at 6¼° to 8¼° Tw., and 77° Fahr. If the shade required is very dark the heat may be raised a little more. Wash well, make up a beck with fustic, extract of indigo, and orchil; add a little alum to draw on the fustic, and acidulate slightly with sulphuric acid for the blue.

Dye at a boil, adding more of any of the colors as the shade may require.

Another Scarlet.

Prepare your silks in stannate of soda at 4° Tw. in the cold; take them through weak vitriol sours, and wash well.

Give a second mordant of red liquor at 8¼° Tw., thickened with calcined starch at the rate of 3½ oz. per 35 fluid ounces of the mordant.

Dry without rinsing for at least twenty-four hours; then rinse and dye with decoction of cochineal. When the color is as deep as is required add nitrate of tin to the same beck.

This process gives scarlets as fine as the former, and with less loss of coloring matter.

The object for the addition of calcined starch is to give the silk more body.

In many dye works scarlets or silks are grounded with annatto.

Aniline Blue Dyed with Soap.

For 11 lb. of silk add to a water 17½ oz. sulphuric acid and 3½ oz. solution of white soap. Stir well up and dye at 158° Fahr., with 1¾ oz. aniline blue, which is added in four successive portions. Wash, brighten with vitriol sours, and rinse.

Aniline Violets.

Acidulate the water very slightly with sulphuric acid and enter the silks. Begin to dye in the cold, adding the color in small successive portions.

Raise the heat gradually up to a boil to level the shade. If the tone is too blue let the beck cool, and take the silks through again.

They are then brightened by one or several successive passages through vitriol sours, and it must be remembered that heat increases the blueness and lessens the redness.—*Chemical Review.*

LIQUEFACTION OF OZONE.

By P. HAUTEFEUILLE and J. CHAPPUIS.

WE have ascertained that the sudden liberation of ozonized oxygen from pressure occasions the formation of a dense mist, the certain sign of a change of the condition of the ozone; but is it possible to obtain this body in the state of permanent drops, and is the liquid ozone colored? This is what we have endeavored to find out by compressing, with the precautions indicated in a former memoir (*Comptes Rendus*, xci., p. 522), ozone prepared at the low temperature produced by passing a current of dry air into methyl chloride. This gas, compressed at 200 atmospheres in the capillary tube of Cailletet's apparatus cooled down to —23°, assumes a blue color, which becomes deeper and deeper as the pressure increases, but which does not yield a visible liquid distinguishable from the gas by a meniscus. If we place the upper portion of the capillary tube in liquid nitrogen protoxide, the intensity of the coloration augments considerably in this portion, which is cooled to —88°. The lower part being kept at —23°, we may judge of the difference of the shade, and estimate that the ozone at —88° is three or four times more deeply colored than at —23°. The intensity of the coloration increases, therefore, as the temperature falls. After a few minutes the temperatures of the two portions of the tube differ but little, and the gas takes a uniform deep blue color. The ozone is then imprisoned in a vessel closed by solidified mercury, the meniscus of which remains brilliant and absolutely unattacked by ozone at this low temperature. Under these conditions it may be ascertained that the capillary tube does not contain a drop of liquid. Do these experiments prove that ozone is blue in the liquid state? Such a conclusion would be strained, for if a gas becomes more deeply colored on cooling it does not follow that it would retain its color on a change of physical condition, although in hyponitric acid we find that the color of the liquid acid and that of its vapor differ so much the less as the temperature falls. But we may endeavor to determine the liquefaction of ozone by adding to the mixture of ozone and oxygen a large proportion of carbonic acid, an artifice which has enabled us to recognize new facts. The comparative study of the mixtures of oxygen with ozone and with carbonic acid has shown us that the liquefaction point of ozone differs little from that of carbonic acid. Not being able sufficiently to increase the proportion of ozone in the mixture so as to diminish the retardation which a large proportion of a permanent gas occasions in the process of liquefaction, we added carbonic acid to the ozonized oxygen. The compression in a capillary tube kept at —23° by means of chloride of methyl, of a mixture of carbonic acid, and of oxygen ozonized at a very low temperature, gives results analogous to those obtained with

mixtures of several liquefiable gases, but which are in this case rendered quite distinct. Slow compression enables us to obtain a liquid separating itself from the gas by a mixture; this liquid is not colorless, as is the case with liquid carbonic acid; it is decidedly blue, and its shade does not seem to differ from that of the gas above. This is a stable condition, which is permanent as long as the gases remain under pressure. If we slightly release the gases and immediately compress again, we see above the mercury a sky-blue liquid column, much more deeply colored than the gas. The cold of the release occasions an abundant vapor formed of carbonic acid and of ozone in the liquid or solid state, for the latter body is then cooled below its critical point, and the plentiful liquefaction of the carbonic acid produced by compression collects a portion of this ozone. What proves that the matter takes place thus is that the coloration of the liquid diminishes, and that in a few minutes the liquid and the gas take the same shade. The ozone collected at first by the liquid carbonic acid becomes diffused, the atmosphere of the tube not containing the vapor of ozone in a state of saturation. In the same manner as the compression of a mixture of oxygen, carbonic acid, and nitrogen monoxide gives a mixed liquid formed of the two liquefied gases, a mixture of oxygen, carbonic acid, and ozone gives a mixed liquid containing liquefied ozone; this ozone gives a blue color to the liquid obtained in our experiments. These facts enable us to foresee that we should obtain ozone in liquid drops by compressing at a very low temperature the mixture of ozone and oxygen prepared at —88°, the proportion of ozone rising, according to our experiments, to more than fifty per cent., and that under these conditions we should have a very deep blue liquid. Colorations have already been employed in chemistry to solve controversy questions. It is sufficient to refer to the experiments of M. H. Sainte-Claire Deville on the dissociation of phosphorus perchloride and mercury iodide. The coloration of ozone in the liquid and the gaseous state enables us to show that the products of the decomposition of carbonic acid by the effluve contain a large proportion of ozone. For this purpose it is sufficient to compress them, which is easily effected by transforming the reservoir of Cailletet's tube into an effluve apparatus, in which the carbonic acid is submitted to electric discharges for several hours before being compressed. The compression of the gas cooled down to —23° gives a gas as colored as its proportion of ozone indicated by M. Berthelot admits of, and at a certain pressure the carbonic acid which has not been decomposed liquefies and turns blue. We establish thus, without any reagent, the large proportion of ozone found in the oxygen derived from the decomposition of the carbonic acid. This conclusion is what has been already indicated in a former paper (*Comptes Rendus*, xci., p. 762), and it is conformable to one of the hypotheses laid down by M. Berthelot on the nature of the oxidizing product formed from carbonic acid by electric discharges.

INFLAMMATION TEMPERATURES OF GASEOUS MIXTURES.

By MM. MALLARD and LE CHATELLIER.

THE detonating mixture of hydrogen and oxygen explodes between 552°—569°, and this temperature is only lowered by 30° if the proportion of oxygen is increased by one-half. The addition of nitrogen to the mixture scarcely causes any difference in the temperature of ignition, which, however, is increased a little by the addition of carbonic acid. The detonating mixture of carbonic oxide and oxygen explodes at 647.5°, and large variations in the proportions of the gases scarcely affect the temperature. An addition of nitrogen has little influence, but the presence of carbonic acid raises the temperature notably. Detonating mixtures prepared with hydrogen monocarbide have not, properly speaking, any precise and definite temperature of ignition, but it is not higher than 790°, and ignition may take place much lower.

TRANSFORMATION OF OXYGEN.

By P. HAUTEFEUILLE and J. CHAPPUIS.

A VERY small quantity of chlorine serves to prevent the transformation of oxygen into ozone. If a very small volume of chlorine is introduced into ozonized oxygen the ozone is completely destroyed during the act of electrization, a very unstable chlorine compound being probably formed. Nitrogen mixed with oxygen enables the latter to be transformed into ozone in a larger proportion than if the latter gas were present alone. Hydrogen and silicon fluoride do not hinder ozonization.

ACTION OF CHLORINE AND OF HYDROCHLORIC ACID UPON LEAD CHLORIDE.

By A. DITTE.

WHEN at a given temperature chlorine is passed into a liquid containing an excess of lead chlorine and increasing quantities of hydrochloric acid, this gas, acting at first upon the chloride dissociated by the water, forms lead peroxide and hydrochloric acid, between which a particular state of equilibrium is established. As the quantity of acid augments there are produced larger and larger quantities of perchlorinized lead hydrochlorate, always dissociated in such a manner that the liquid contains constantly hydrochloric acid and free chlorine.

ENRICHMENT OF PLUMBIFEROUS EARTH BY MEANS OF A STREAM OF AIR.

By M. DELESSE.

A BLAST apparatus has been employed to remove the lighter particles from certain pure plumbiferous earths, containing originally not more than seven per cent. of metal. The process was not found applicable when the grains of earth were very minute. The proportion of silver was found to decrease as that of lead increased. The process did not work satisfactorily wtih the galena of Génolhac with a quartzose and dolomitic gangue.

THERMIC EQUILIBRIUM OF CHEMICAL ACTIONS.

By DR. DONATO TOMMASI.

THE author proposes the solution of the following problem: When any compound such as can be oxidized and reduced is submitted to a chemical action, which is at the same time oxidizing and reducing, in what manner will such compound behave, being in presence of two forces equal and opposite? The paper is to be continued, and does not appear to admit of useful abstraction.

HEAT OF FORMATION OF DIMETHYL.

By M. BERTHELOT.

THE author maintains that dimethyl or ethylene hydride constitutes a link, at once theoretic and experimental, between the methylic series—toward which it plays the part of a radical both by its formula and its origin—and the ethylic series which it develops by its methodical transformations. Between formene and dimethyl pyrogenous reactions even establish the existence of certain mobile equilibria where these two bodies produce each other reciprocally. The transformation of formene into dimethyl takes place by the separation of hydrogen according to the same volume proportions as the decomposition of the hydracids. The thermic relations between dimethyl and the methylic compounds do not differ greatly from those which exist between hydrogen or the easily reducible metals and their binary compounds. But there is this essential difference, that hydrogen and the metals play the part of radicals, both analytically and synthetically, while dimethyl, formed analytically at the expense of the methylic compounds, does not in general reproduce them by direct synthesis.

CYPRIEN M. TESSIE DU MOTAY.*

By AUGUSTE J. ROSSI.

BY the death of Mr. Tessie du Motay, the American Chemical Society has to deplore not only the loss of one of its most distinguished members, but also that of a *savant*, who will leave by his numerous works, discoveries, and researches in all branches of technology, a lasting impression on the history of industrial science of our century. He died suddenly, in New York, from apoplexy, at the age of 61 years.

Born in Brittany, France, in 1819, of an old and aristocratic family, Tessie du Motay received in his youth an academical, but not technical education. His studies were directed by the famous Abbe Lamennais—a friend of his family, from whom, it must be supposed, he derived his very liberal ideas in politics and philosophy. Gifted with a brilliant and passionate imagination, of a distinguished, and at the same time romantic, turn of mind, as well as of a superior intelligence, he could not but take an active part in the conflict between the "Romantic" and "Classical" Schools, as the two parties were called which divided the young generation of *literati* in the first years of the monarchy of Louis Philippe. Brilliantly endowed as a literary man, his first essays opened to him the doors of the most renowned *salons* of this period, where French art, literature, and science made their abiding place. Even the most exclusive of these opened its doors to one so well fitted to do honor to it, and in the *salon* of Madame Recamier, young Tessie du Motay met with great success in his efforts in the drama, poetry, and music. Chateaubriand and Victor Hugo were the familiars of this "*Cenacle*," and there Tessie du Motay became acquainted with Alfred de Musset, Vigny, Scribe, Theophile Gauthier, Mery, Gerard de Nerval and all this pleiad of young authors, who have since acquired a prominent place in different branches of literature.

But science had also its fascination upon him; the frequenting of the society of such eminent chemists as Chevreul, Dumas, Berthelot, decided his calling; more especially Chevreul, who was an intimate friend of his father—Chevreul who, at the age of eight years, held M. du Motay's father in his arms for baptism. Some early discoveries encouraged him to persevere, and finally, by continuous efforts in France and abroad, he conquered for himself a name well known and appreciated in the history of industrial chemistry. Ardent to the task, never sparing the means he had been able to acquire in his professional career as consulting chemist, there has not been a single important subject in technical science developed within the last twenty years in which Tessie du Motay was not directly or indirectly concerned. Of a generous and open nature, he often gave to manufacturers who consulted him new processes in industry, or happy modifications of old ones, which were applied by them, and of which the origin cannot be publicly traced to him.

An ardent and radical republican, brought up in the midst of the liberal agitation of those times, a warm advocate of free speech, free press, and free education, he has, in politics, a record that the friends of liberty and liberalism cannot forget. He took, as might be expected, a leading part in all the exciting events of the last years of the Monarchy of July, 1830. He participated, at the side of Ledru-Rollin, in the political movement of 1848, and the subsequent agitation.

Exiled from France, after what is known there as the "Bourges Trial," in 1849, he went successively to Belgium, England, and Germany. In England, he renewed acquaintance with the prominent exiles, Ledru-Rollin, Louis Blanc, Caussidiere, Madier de Montjau, all of whom have since become well known.

When abroad, he completed many of his most important discoveries. He returned to France in 1860, and applied himself from that time entirely to industrial chemistry, which secured for him two gold medals and one silver one at the different International Exhibitions in Paris, in 18 5 and 1878, and finally, the Cross of the Legion d'Honneur. During the siege of Paris he directed the service of the ambulances, and all those who had occasion to know him then, and to see him at work, can testify with what devotion, what cheerful humor, and, at the same time, with what patriotism, he took his part in the national defense. He was on the staff of the Governor of Paris, and was present at the most important battles of the siege, that of Champigny and others.

A literary man, a musician, a philosopher, and a *savant*, Tessie du Motay was also one of the most honorable and sympathetic of men. Nobody, better than he, knew how to ally to the genial courtesy and affability of the man of good society, the dignity and the seriousness of a perfect gentleman. The interest and charm of his conversation, the amenity of his intercourse, made him the most fascinating of men, as he was also the truest of friends. Generous, kind-hearted, always ready to help misfortune wherever met, during a stay of hardly eighteen months in the United States, he had succeeded in creating around him a circle of appreciative and devoted friends, who held him in the highest regard. Young and old were attracted to him, fascinated as it were, by the magical charm of his conversation. Even in his later days he did not give up his literary pursuits. He had great fondness for Oriental literature and the mythology and theogony of India. We were fortunate enough to have the privilege to hear him read his translation, or rather adaptation, in French verse (with many original and happy additions inspired by the subject) of some of the songs of Brahma and Vishnu. The enthusiasm of his diction, the genuine animation of his gestures, could well make one believe himself to be transported, in reality, into the poetical fictions of Brahmanism and Buddhism. He also left a philosophical drama which he desired should not be published until after his death, which, under the name of the "Expiation of Faust," treats of an old subject in a novel and masterly manner.

* From the *Journal of the American Chemical Society*, July, 1880.

TESSIE DU MOTAY'S SCIENTIFIC WORK.

It was said of him that he made perhaps more inventions than any other man, for it often happened that when he was consulted about some scientific subject, he would give expression to views so original, and make suggestions so practical, that his consulters often utilized them at once, without his receiving the credit of the suggestion or invention. About eighteen months previous to his death, he had come to the United States as consulting chemist and engineer of the Municipal Gaslight Company, to superintend the building of retorts and furnaces, and the preparation of machinery for the introduction of the carbureted water gas, practically and on a large scale, for the lighting of New York. Everybody knows what success he has met with. The gas obtained has a much greater illuminating power than the ordinary gas, and can be produced at such reduced rates as to have forced many of the other companies to adopt the process.

Metallurgy.—Metallurgy greatly interested him, and he was intimately connected for the last twenty years with the progress of this science. He patented in England a process for the treatment of arseniferous iron ores, and suggested or made several improvements in the manufacture of ferromanganese. He was also the first to introduce and manufacture bricks of magnesia for metallurgical purposes. They were made for Mr. de Wendel, in Alsace, for the Siemens-Martin steel furnaces. The magnesia was brought from Eubœa, Greece, in the state of magnesite (magnesium carbonate). The earth was ground, worked in the shape of bricks, which were compressed by hydraulic pressure of 100 tons. They were then burnt in a kiln at a very intense temperature, so as to prevent the magnesia from changing to carbonate on contact with the air. The best Dinas fire bricks, used at Mr. de Wendel's, lasted generally from two to three weeks, whereas the magnesia fire bricks of Tessie du Motay lasted eighteen months. They were used by Mr. de Wendel in forty reheating furnaces for steel and iron with great success.

In the fall of 1879, Mr. du Motay was engaged by certain capitalists to make an examination of, and report on, the iron and copper pyrites deposits of Lake Superior and Canada. He was to have undertaken the direction of the reduction of these ores by a new process of his own invention when death struck him.

Etching on glass.—In collaboration with Marechal, he invented and introduced a very excellent method for etching on glass. The use of hydrofluoric acid is always attended with danger, especially when it is in the gaseous state. But while the solutions of this acid produce on glass brilliant surfaces, it is only by the use of the gas that it is possible to obtain unpolished surfaces, much finer and better adapted for delicate effects in decoration. By his process excellent results have been obtained, and the dangers of the gas avoided. The hydrofluoric acid is disengaged in the nascent state from a bath composed of fluorhydrate of fluoride of calcium, water, and diluted hydrochloric acid. He recommended also the use of saccharate of lime as a counteragent against the burns produced by fluorhydric acid.

Photography.—In photography he improved several processes, and, at the same time as Poitevin and Niepce, made several attempts for the production of colored photographs. In connection with Marechal he invented a special process for the production of transparent vitrified photographic proofs. A glass plate having been covered with a solution of India-rubber in benzine, and, when dried, with a coating of iodureted collodion, an image (positive by transparency) is obtained from the negative. After proper treatment by means of cyanide of potassium, platinum, and gold baths, to develop and obtain the proper shades of black, the plate is placed in a muffle, and the organic matters burnt. It is then covered with a flux of borax and vitrified.

Electric light.—Tessie du Motay has been connected with the latest efforts made for the introduction of electric light, on an industrial scale, for illuminating cities. A professional friend of Jablochkoff, Moncel, and Jamin, and other celebrated electricians, he, with Jablochkoff, was the first to suggest the use of carbon pencils coated with kaolin, to prevent their disintegration when burning.

Edison, in his latest electric lamps, realized this idea by using the carbon produced by the calcination of bristol boards; mistaking the true explanation of the case, he attributed to a fourth state of carbon the peculiar properties of the carbon thus obtained.

Tessie du Motay (in an article which was published in the New York papers) explained that the qualities of durability of these new pencils were due to the presence of kaolin, used for sizing bristol paper, and that he and Jablochkoff had many years ago anticipated the idea.

Permanganates.—He gave his attention to the preparation of alkaline permanganates on a large scale, having found an industrial use for them in his new method of preparation of oxygen gas. In the ordinary preparation of the permanganate, peroxide of manganese, chlorate of potash, and caustic potash are heated together in an iron retort. After proper manipulations the mass is treated with water, which transforms the manganate into permanganate. Tessie du Motay proposed first to produce the transformation of manganate of potassium into permanganate, by means of sulphate of magnesia. He also obtained the alkaline permanganates by a completely new process, by the action of the oxygen of the air on sesquioxide of manganese in presence of caustic soda or potash. The mixture, introduced into cast iron retorts, is heated to 400° C., and a current of air is passed through the mass.

Preparation of oxygen.—One of his most original, ingenious, and successful inventions was that of the preparation of oxygen gas on an industrial scale. His method is based on the following reactions: When the permanganate of sodium or potassium is exposed to a temperature of 450° C., in a current of superheated steam, the salt loses its oxygen, producing caustic alkali and peroxide of manganese. If now this mixture of these two substances, at this same temperature of 450° C., is exposed to the action of a current of air, the primitive salt is regenerated by absorption of oxygen, and can then furnish oxygen anew by the action of superheated steam. In consequence of these successive decompositions and revivifications, a given quantity of permanganate can furnish an indefinite quantity of oxygen. The operation is effected in cast iron retorts. The steam

carried away by the oxygen gas is condensed, and the air from which oxygen is to be borrowed for the regeneration of the permanganate is blown in the retorts after having been deprived of its carbonic acid. By this method one cubic meter of oxygen cost 0·40 franc.

Illuminating gas.—Having thus secured the means of obtaining oxygen cheaply and in great quantities, Tessie du Motay turned his attention to one of his favorite schemes, and one which has brought him a legitimate share of his fame—"a new method of illumination."

In the Drummond light, a mixture of oxygen and hydrogen gas, supplied by two different gasometers, is brought in contact with a cylinder of caustic lime, and lighted. A light, next in intensity to that of the sun or electric arc, is thus produced. Tessie du Motay and Marechal have rendered this system applicable even to the lighting of cities, by the introduction of their industrial method for the preparation of oxygen gas. Tessie du Motay modified the process in preparing the hydrogen gas, by effecting the decomposition of hydroxide of calcium by carbon in iron retorts. A company, under the name of the New York Oxygen Co., has employed this system of illumination with success for large squares, public places, beacons, signals. It was very much used during the war of secession.

Guided by Caron, Tessie du Motay and Marechal have since substituted for the calcium pencil a pencil of calcined magnesia, which withstands better the high temperatures which are reached. These pencils having sometimes the inconvenient property of breaking on cooling, they have substituted for them the "zirconia pencils" with much better results.

Tessie du Motay has also introduced a new system of illumination by using water gas (a mixture of hydrogen and carbonic oxide), which is burnt in the presence of a regular current of oxygen, obtained by his process. The flame is directed on cylinders of magnesia and zirconia. This system was tried in Paris, Place de l'Hotel de Ville, in 1868, with success.

In 1870, Tessie du Motay modified his methods in the following manner: He made his oxygen pass into the flame from a solution of naphthalene in petroleum ether. This liquid was called in France, "carbolene." During the combustion there are separated from the liquid substances of an intense lighting power. This kind of light is known in France as the "oxy-carbureted light of Tessie du Motay." The combustion took place in lamps with a wick (Philipp's lamps), into the flame of which the oxygen gas penetrated horizontally.

After these experiments, Tessie du Motay still further modified his system, and gave it a very practical form, by directing a jet of oxygen gas on ordinary illuminating gas from coal, made very rich in carbon by proper carburation, the combustion taking place in a slit burner of steatite. This process was tried in Paris, in 1870, on the Boulevard de l'Opera, and at the Tuileries, under the auspices of Napoleon III., who was very enthusiastic on the subject. The light, it is said, was intense and really splendid. If it had not been for the complications which the war brought on, this system bade fair at the time to be thoroughly tested and employed in Paris. It was on this occasion that he received the cross of the Legion d'Honneur, he having refused it once before, on account of his political record, because it had been officially sent to him. The Emperor gave him an audience, and, having learned his reasons for refusal, took from his coat the cross he was wearing himself and attached it to the bosom of Tessie du Motay, adding that "science and politics had nothing to do together."

Though found objectionable on account of the double system of pipes required, this system of illuminating can be, and, in France, has been, applied in many cases. It has been applied to the lighting of mines, for photography, for submarine works, for lighting public places of meeting, theaters, etc. The industrial preparation of oxygen by the du Motay process constitutes certainly a progress very interesting and full of promise for the industry of illuminating gas.

Tessie du Motay still further modified the burner for his gas, by the introduction of his "differential burner." The ordinary illuminating gas, carbureted as before, arrives in two opposite directions by two tubes which are curved horizontally. The oxygen is supplied by a vertical tube reaching slightly below the level of the others, and placed between the two. This burner is formed of several jets of the same kind, placed in a ring. A vertical magnesia or zirconia pencil is slightly engaged at its base in the ring formed by the jets, and becomes incandescent.

Bleaching.—The name of Tessie du Motay is associated with several inventions for the bleaching of textile fabrics and fibers.

In 1874, Tessie du Motay proposed for the scouring of silk (to deprive it of the sericine) the use of a bath of hydrate of baryta (12 to 15 per cent. of the hydrate for 100 of the silk) heated to 80° C. The ordinary decolorizing agents having no action on what is called "gray silk," he proposed to use successively, to bleach these fibers, nascent oxygen gas and sulphur dioxide, sulphydric acid and sulphur dioxide.

The silk is dipped in a solution of permanganate of potassium, and then in a solution of sulphur dioxide, to eliminate the oxides of manganese. After repeated treatments in these solutions, the fibers are introduced into a solution of sulphydric acid, or of alkaline sulphides, washed, and again treated with sulphur dioxide solutions.

For bleaching flax, hemp, cotton, silk, and wool, Tessie du Motay has introduced a new method based on the use of the alkaline permanganates. A solution of manganate of sodium is added to a solution of sulphate or chloride of magnesium, or chloride of calcium; by double decomposition, permanganate of sodium, sulphate of sodium, and hydrate of magnesium, or calcium, are produced. The fibers are dipped in the solution: 2 to 6 kilogrammes of manganate is said to be sufficient for 100 kilogrammes of cotton, flax, or hemp. The fibers are then passed into an alkaline solution, in case of silk or wool in a solution of soap, and afterwards into a solution of sulphur dioxide, to dissolve the oxides of manganese.

The results obtained on a large scale at Comines, France, at the manufactory of Verlay, in 1867, showed that by Tessie du Motay's process it is possible to bleach completely in a day the fibers of flax and hemp, and that but three days were required for tissues of flax and hemp, and it was claimed that the fibers were no more injured than by the other processes in use, which, moreover, necessitate a much longer time. For 100 m. of linen the cost was stated at six francs. The manganate of sodium could be obtained at one franc per kilogramme.

He has also introduced a new method for bleaching wax and feathers, which is at present carried on in France, by Messrs. Viol & Duflot. It is based on the use of oxygenated oil of turpentine.

Industry of sugar (baryta).—In the ordinary process of the treatment of sugar solutions, the sugar is separated from the impurities by the addition of lime and other substances, capable of forming with these impurities insoluble compounds, the sugar remaining in the solution. Dubrunfaut and de Massy have introduced in France a new method of treatment, which is the reverse of the preceding. It consists in separating the sugar from the impurities it contains, by forming with the sugar an insoluble compound, while the impurities remain in the solution. The substance employed is hydrate of baryta, which forms with cane and beet sugar, even at the temperature of ebullition, insoluble saccharate of baryta.

To render this method practicable, hydrate of baryta had to be obtained at a sufficiently low price, and on a large scale. Dubrunfaut and Liplay prepared it by the decomposition of witherite (barium carbonate) by coal. But this decomposition to be complete requires the highest temperature, which the kilns used were not able to stand.

Tessie du Motay, in connection with others, has contributed his part to the solution of the problem, and to the introduction of another and much more economical process. This process has been successfully carried on in France, at Comines (Nord), at Asnieres les Paris, at Courriere (Pas de Calais), at Menu Tylloy Delaune. It is based on the decomposition of natural barium sulphate (barytes), by coke, and subsequent treatment of zinc oxide.

The mineral is ground, mixed with 20 per cent. of coke or soft coal, and calcined in a Siemens-Martin furnace. Barium sulphide is thus formed. This sulphide is suspended in water, steam is admitted, and the mass is thoroughly agitated. It is then allowed to settle. The supernatant liquid and the concentrated washings of the residue are received in proper vessels. This liquid is of a complex composition; it contains diluted hydrate of baryta, barium proto and bisulphide, and baryta sulphydrate. The sulphur is eliminated by boiling the liquid, after an addition of zinc oxide (300 kilogrammes zinc oxide for 35 hectoliters of sulphurous liquid at 25° B.), the mass being thoroughly agitated all the time. Insoluble zinc sulphide is formed, and baryta hydrate remains in solution. The solutions are concentrated, allowed to crystallize, and the crystals are dried in the "centrifuge." The product is hydrate of baryta with nine equivalents of water. The zinc sulphide is washed, roasted in ovens, and the zinc oxide is thus regenerated for another operation.

Binoxide of barium.—Tessie du Motay, starting from the baryta, has also modified and improved the ordinary process of preparation of binoxide of barium from this base.

Artificial ice.—In 1880, Tessie du Motay and A. J. Rossi patented two new processes for the artificial production of ice and cold, based on the power of absorption, which they find certain ethers and alcoholic radicals to possess, for gaseous sulphur dioxide and ammonia.

In one of them, a mechanical power is used to produce the volatilization of both constituents of the binary liquid, the vapors of which are compressed under very small pressure in a condenser, where the ether liquefies easily, absorbing the vapors of sulphur dioxide, reconstituting the original liquid, and thus avoiding the high pressures necessary to liquefy the sulphur dioxide by mechanical compression.

In the other, advantage is taken of the higher point of ebullition or less volatility of the absorbing ether. No mechanical power is required. The sulphur dioxide is disengaged by the action of heat (a water bath) from the absorbent contained in a boiler, and condensed to the liquid state, by proper cooling and the pressure the gas exerts on its own molecules.

The fire being removed from the boiler, and the latter cooled in its turn, the liquid dioxide evaporates under the partial vacuum thus produced, generating an intense cold, its vapors being absorbed as fast as they are formed by the absorbent in the boiler, working much in the same manner as the Carre ammonia solution machines, but with much less pressure, and with a water bath instead of a furnace.

In 1879, Tessie du Motay, in collaboration with L. F. Beckwith, took out in the United States several patents of a mechanical character, for small rotary motors, for mechanical devices, for the application of the cold produced by refrigerating machines to the ventilation and cooling of mines, for improvements in steam condensers used on board of steamers, by using a very volatile liquid, such as sulphur dioxide, for condensing steam, instead of water, the volatile liquid being thereby volatilized under high pressures, the mechanical action of which could be utilized on a piston so as to restitute part of the mechanical power otherwise lost in the condensing water. He also took a patent with L. F. Beckwith, for the joint use in the same ice machine, of sulphur dioxide and chloride of methyl, with the idea of using the former as an extinguisher of the latter.

PICRIC ACID IN BEER.

By Dr. H. Fleck.

The author evaporates 500 c.c. of the beer to a sirup, mixes with ten times its volume of absolute alcohol, filters off the precipitate, washing it as well as possible, and evaporating the alcoholic filtrate to dryness. The residue is extracted with water at a boil as often as the liquid becomes colored, evaporates to dryness, and extracts the residue with ether. The ethereal extract contains the picric acid almost pure.

MALLEABLE CAST IRON.

By M. L. Forguignon.

Malleable cast iron appears as an intermediate body between steel and gray pig-iron, from which it differs by the special nature of its amorphous graphite, and by its greater tenacity; it is distinguishable from steel by its slight extensibility and its large proportion of graphite.

NOTE ON SIEMENS-MARTIN STEEL.

By Sergius Kern, M.E., St. Petersburg.

In most cases this steel is used for shipbuilding and boiler-making. In the manufacture of plates the author has noticed that the Siemens-Martin ingots stand a better heat and roll more softly than Bessemer ingots containing the same quantity of carbon. Moreover, Siemens-Martin ingots contain, as a rule, less manganese than Bessemer ingots, and as plates containing much manganese are more liable to oxidize, the Siemens-Martin plates are preferable for the above-mentioned purposes.

The following table shows what beautiful results are obtained in testing Siemens-Martin steel. Giving a high elongation, it shows a good breaking-strain, taking into consideration the percentage of carbon (0·45 to 0·60 per cent). Bessemer steel containing the same amount of carbon never gives such results. The specimens tested were intended for other purposes than plate-rolling, but by annealing most of this steel will be quite good enough to stand Lloyd's tests:

Siemens-Martin Steel.

Length 8 in.; thickness ⅜ in.; percentage of carbon 0·45 to 0·60.

Samples.	Breaking Strain. Tons per Sq. Inch.	Elongation. Per cent.
1.	34·49	18·40
2.	33·15	21·10
3.	35·81	20·00
4.	42·53	20·00
5.	34·49	21·00
6.	38·03	16·60
7.	43·65	19·10
8.	36·93	20·00
9.	44·29	16·10
10.	40.29	17·40
11.	40·50	23·70
12.	31·80	20·30

—*Chemical News.*

THE ACTUAL FIGURE OF THE EARTH.

By Dr. Geo. W. Rachel.

I.

M. Faye, the well-known French scientist—well known by his excellent observations, as much as by his numerous bold theories—has lately addressed to the French Academy of Sciences a paper on the physical forces that have produced the present figure of the earth. An epitome of its contents has been given in the Scientific American.* The most important portion is that which refers to a fact hitherto very little noticed. It is this:

That attraction is greater above the oceans than over the great continents. Of this peculiar phenomenon M. Faye offers the following explanation:

That under the great oceans the globe cools more rapidly and to a greater depth than beneath the surface of the continents, etc.

This explanation can hardly be called a happy one; for, supposing even the earth was really as thinly shelled as this view would seem to require, the pressure of the continents, having a specific gravity ranging between two and three, and rising many thousands of feet above the level of the sea, would materially alter the result. The density of the underlying strata would be considerably increased, and probably equal to that of the upper submarine layers, having about the same horizon. There would, therefore, be an equilibrium established, and the lifting-up process to which M. Faye ascribes the rising of the continents would be, to say the least, rather problematical.

The liquid state of the earth's interior has, however, of late been questioned by many scientists, and even the nebular hypothesis itself—although one of the most ingenious speculations ever broached by the human mind—is looked at rather skeptically by some. An elaborate discussion of this subject, however, does not come within the scope of this article, although it is of peculiar interest. For one of the greatest astronomers of our country considers the nebular hypothesis *"a very doubtful thing,"* and thinks *"that many facts are against it!"*

But, aside from this, we have in regard to the alleged molten state of our earth's interior not merely opinions of excellent authorities; we are in possession of facts which disprove the truth of this assumption. As to opinions of competent men, we will quote the following passage from a work of Prof. Newcomb:†

"But mathematicians have never been able entirely to reconcile the theory in question with the observed phenomena of precession, nutation, and tides. To all appearances the earth resists the tide-producing action of the sun and moon, exactly as if it were solid from center to circumference. Sir William Thomson has shown that if the earth were less rigid than steel, it would yield so much to this action that the tides would be much smaller than on a perfectly rigid earth. . . . If the earth were only a thin shell, floating on a liquid interior, the tides would be produced in the latter; the thin shell would bend in such a way that the tides in the ocean would be nearly neutralized."

Now as to the facts alluded to above.

As is well known, the temperature rises when we descend into the earth. This increase of temperature has been supposed until lately to average about 1° C. to 100 ft; this, if continued at the same rate of increase from the lowest strata ever reached by man, would seem to show that everything must be red hot at a depth of 12 miles, while at 100 miles the temperature would be high enough to melt almost every known body. To this way of reasoning, however, a very strong objection may be raised, viz., this: that it is a very inaccurate and wholly unscientific procedure to apply a law to hundreds of miles that has been deducted from observations ranging between three and four thousand feet only. It cannot be surprising, therefore, that there are various observations recorded widely at variance with this assumed law. Two of these have moreover been made in borings which are of the deepest ever accomplished. One of them shows absolutely no law at all, while the other even proves a constant diminution of the increase of temperature.

The first set of observations was made near the Insane Asylum of St. Louis Co., Mo. A well was bored there to a depth of 3,843½ feet, in which measurements of temperature were made with a Fahrenheit registering themometer by Mr. C. W. Atkinson, who superintended the work. In the report‡ of Col. G. C. Broadhead, State Geologist of Missouri, the following table of results is given:

Depth. In feet.	Depth. In meters.	Temperature. Fahrenheit.	Temperature. Celsius.
3,127	953·09	106°	41·11°
3,129	953·70	107°	41·66°
3,264	994·84	106°	41·11°
3,376	1028·98	106°	41·11°
3,473	1058·55	105°	40·55°
3,533	1076·83	105°	40·55°
3,604	1098·48	105°	40·55°
3,641	1109·75	104½°	40·28°
3,728	1148·46	105½°	40·83°
3,800	1158·22	105°	40·55°
3,837	1169·49	105°	40·55°

* No. 13, Sept. 25th, pp. 200 and 201.

† "Popular Astronomy," Harper & Bros., 1878, p. 300.

‡ Trans. St. Louis Academy of Sciences, Vol. III., No. 2, pp. 221-[illegible]

Col. Broadhead very correctly adds:

"It is to be regretted that no tests of temperature were made *above* these indicated depths."

A single glance at the table shows that for the lowest 700 feet of this well there is no constant ratio of increase whatever; there is not even a constant increase. For the highest temperature recorded (107° F.) was found to prevail at 3,129 feet, or 700 feet above the bottom; while the lowest (104½° F.) was registered at 3,641 feet, or 500 feet below the former, and 200 feet above the lowest point. The objection to these measurements is, that they were crudely arranged and insufficient in number, so that they might be challenged as to their accuracy.

This cannot be said, however, of the other observations referred to above, which were made in a boring deeper yet than the foregoing. For these measurements were made after due deliberation and careful preparation by German mining officials of high standing. They were executed with that utmost care and circumspection which we are wont to find as a sterling property of German scientists—especially those in government service. The boring was made in the neighborhood of the German capital, near a small place named Speremberg, situated about 25 miles south of Berlin. Although an increase was always registered, yet the amount of increase grew steadily smaller, and would have been found to disappear entirely could the work have been pursued for several thousand feet further down. This is evident from the following table,* which gives the rate of increase per 100 feet in various depths.

Depth in Rhen. feet	Increase of Temp. per 100 feet. Reaumur.	Fahrenh.
900	1·097°	2·468°
1,100	1·047°	2·356°
1,300	0·997°	2·243°
1,500	0·946°	2·182°
1,700	0·896°	2·018°
1,900	0·846°	1·904°
2,100	0·785°	1·789°
3,390	0·608°	1·368°

While for the lowest 100 feet it was 0·445° R., (1·001° F.).

It is indisputable that this diminution of increase would have resulted in its complete disappearance if a continuance of the work would have been feasible. The depth at which this takes place has been variously estimated at from 5,000† to 100,000‡ feet. At all events it may be assumed that the temperature at this point will not be high enough to melt lead, since the highest temperature recorded at the depth of 3,390 feet—862 feet above the bottom—was found to be:

$$36·756°\ R. = 114·701°\ F.$$

It is evident from the foregoing that such "a very doubtful thing" as a molten interior should at present be used in scientific discussions in a very guarded way. There is already quite a number of scientists who have discarded this hypothesis entirely; they consider the earth as solid throughout, and the volcanic regions—which constitute after all only an insignificant portion of the earth's upper strata—they declare to be due to local causes. (Hopkins, Karl Vogt, Karl Fuchs, Sterry Hunt, Sir Wm. Thomson, Poulet, Stroup, and others.)

The subject in question, however, does not at all necessitate an explanation by means of such an improbable hypothesis as a molten interior. The greater intensity of gravity on oceanic islands allows of satisfactory explanation, which is not only in full accord with the laws of gravitation, but which will ultimately lead to a definite solution of the problem whether the true figure of the earth is an ellipsoid with three different axes, as is held by many at the present time, or whether it really is what theoretically it should be: *a rotatory ellipsoid*. And finally, it will give an opportunity for a definite determination of the proportion between axis and equatorial diameter.

Before proceeding to give this explanation, and at the same time prove its correctness, it is proper to recall the results of the more important attempts that have been made to determine the true figure of the earth. The arduous labors of the numerous scientists, and the liberal support of the various governments interested in the solution of this problem, combine to form one of the most brilliant chapters in the history of human progress. And although it has been reserved for our century to find the real solution, it was only due to the methods employed by these men that they did not succeed in permanently settling this question, not to any want of intelligence and assiduity on their part.

The first successful attempt—not including the labors of Eratosthenes (276–192 B.C.) and Posidonius (135–51 B.C.), which were accurate enough considering the rudimentary knowledge and the limited means of observation of these ancient philosophers—to measure the length of a meridian was made by Pierre Picard (1669 A.C.). By the method of *triangulation* devised by Snellius, who was prevented by sudden death from completing a similar task, Picard determined the length of one degree; the distance between the two cities of Paris and Amiens, situated on the same meridian, was known to measure this exactly. But his results were loaded with many errors of observation and calculation—they gave too small values. The consequence was that other surveys, made in the south of France, gave larger values by 800 to 1,000 feet as the actual length of one degree. This seemed to point to a peculiar lemon-shape of the earth, a view which was untenable in the face of the elder Cassini's observations, and Newton's and Huyghens' calculations. For just about that time the great Italian had measured Jupiter's oblateness, and the great Englishman, as well as the renowned Dutch philosopher, had pointed out the centrifugal force as the cause of this flattening at the poles, and calculated the same to amount at the poles of our planet to from 20 (N.) to 75 (H.) miles.

To settle this important question the French Academy of Sciences organized two expeditions, one of which was sent *north* (to Lapland), and the other *south* (to Peru). While the results of these expeditions were being prepared for publication, the younger Cassini carefully revised Picard's surveys and calculations and corrected them, thereby materially changing the result. Thus, at last, the length of one degree was found to be:

	Toises.	Feet.	Meters.
In *Lapland:*	57,437	344,622	111,955
" *France:*	57,012	342,072	111,116
" *Peru:*	56,753	340,518	110,616

This seemed to close the discussion as to the real figure of the earth; the *lemon-shape* was no longer tenable, and the *orange-shape* had to take its place. Thus Newton's and Huyghens' theory of the earth's oblateness was confirmed beyond the possibility of any doubt. Soon, however, it was found that the curvature of different meridians, nay, the curvature of one and the same meridian in different latitudes, was not at all as uniform as theory requires them to be. The radius of curvature was found to be so changing that the apparent figure of the earth could not be said to resemble a *solidum revolutionis* at all. It does not seem to approach the theoretical figure of a rotatory ellipsoid, but rather resembles an ellipsoid with three different axes. These apparent irregular variations of curvature have also been the cause that the flattening at the poles has been found by different authorities to range from $\frac{1}{302}$ to $\frac{1}{317}$ of the earth's equatorial diameter.

But the earth must of necessity be a rotatory ellipsoid, since the two agents to which its figure is due—*attraction* and *centrifugal force*—act on it exactly as theory requires. It is of no account whether—as is generally supposed—the earth was shaped when in a state of original fluidity, or whether its present figure is supposed to be due solely to the great body of water, covering over three-fifths of its surface.* The truth of this proposition has been established by the calculations of such an eminent authority as G. C. Stokes, in a paper *"On the Variations of Gravity on the Surface of the Earth."*†

He says there:

"On adopting the hypothesis of the earth's original fluidity, it has been shown that the surface ought to be perpendicular to the direction of gravity; that it ought to be of the form of an oblate spheroid of small ellipticity, having its axis of figure coincide with its axis of rotation, and that gravity ought to vary along the surface according to a simple law, leading to the numerical relation between the ellipticity and the ratio between polar and equatorial gravity, which is known by the name of Clairaut's Theorem. Without assuming the earth's original fluidity, but merely supposing that it consists of nearly spherical strata of equal density, and observing that its surface may be regarded as covered by a fluid, inasmuch as all observations relating to the earth's figure are reduced to the level of the sea, Laplace has established a connection between the form of the surface and the variation of gravity, which, in the particular case of an oblate spheroid, agrees with the connection which is found on the hypothesis of original fluidity."

And again:

"The near coincidence between the numerical values of the earth's ellipticity, deduced independently from:

"1. Measurements of arcs;‡

"2. The lunar inequalities (which depend on the earth's oblateness);

"3. Pendulum experiments (calculated by means of Clairaut's Theorem);

is sometimes regarded as a confirmation of the hypothesis of original fluidity. It appears, however, that the form of the surface (which is supposed to be a surface of equilibrium) suffices to determine both the variations of gravity and the attraction of the earth on an external particle, and, *therefore, the coincidence in question*, being a result of the law of gravitation, *is no confirmation of the hypothesis of original fluidity*."

And while reviewing the mathematical results arrived at in his calculations, the able Secretary of the Royal Society continues:

"The earth may be regarded as bounded by a surface of equilibrium, and therefore the (mathematical) expressions previously investigated may be applied, provided the sea-level be regarded as the bounding surface, and *observed* gravity be reduced to the level of the sea by taking account only of *the change of distance from the earth's center*."

Having thus paved the way for further inquiry, he attacks the problem with which M. Faye has—not very successfully—grappled, and arrives at conclusions directly opposite to those of the great Frenchman. He says:

" . . . It is an interesting question to consider whether the observed anomalies in the variation of gravity may be attributed wholly or mainly to the irregular distribution of land and sea at the surface of the earth, or whether they must be referred to more deep-seated causes.§ . . . Since a level surface is everywhere perpendicular to the vertical, it follows that the sea-level on‖ a continent is higher than it would be at the same place if the continent did not exist. . . . It appears probable that *the observed anomalies in the variation of gravity are mainly due to the irregular distribution of land and sea on the surface of the earth*."

The observations of gravity, referred to by Mr. Stokes, are to be determined by pendulum experiments, and it is one of the most splendid results of his investigations that he has shown thereby how the real figure of the earth can be determined just by such experiments. For, as we have seen, the results of these pendulum experiments are not at all affected by this or that hypothesis in regard to the distribution of density in the earth's interior.

In this manner we may determine the real figure of the earth, independently of all the other means of observation, and with the least possible error. What we may expect from this method, and how far the somewhat meager results it has until to-day accomplished may justify us in advocating its universal application, will form the subject of another paper.

II.

We have mentioned in our last paper the fact that the results of all the various surveys have revealed apparent differences of curvature, not only for different meridians, but even for different portions of the same meridian. We have also suggested the source of error to which very probably all these apparent abnormalities are due, viz.: *To variations in the intensity and direction of gravity.*

A. The *intensity* of gravity is subject to three causes of variation, viz.:

1. *The distance from the earth's center;* and
2. *The quality of the intervening medium*, whether solid (land) or liquid (sea), and the *depth of the latter.*
3. The intensity of centrifugal force.

B. The *direction* of gravity is subject to *one* cause of variation, viz.:

The *proximity, extent, and mass of elevations, i. e.* hills and mountains on level land, and the continents bordering oceans.

To begin with the last, it is well known that Hutton and Maskelyne were the first to determine by actual measurement the deviation of the direction of gravity caused by an isolated mountain. They found that the Schiehallion *changes the direction of the lead from the true vertical by about 5½ seconds.* Others confirmed this result by determining the deviation caused by other mountain ranges. Col. Stebnitzki, of the Russian army, for instance, found the deviation caused by the Caucasus Mountains to amount to nearly 36 *seconds.* The only exception to this rule seemed to be the gigantic Himalaya range, which, according to the calculations of Bessel and Airy, on the basis of the results obtained by the great Indian triangulation, did not show any deviation of the lead. The first who doubted the accuracy of these results was Pratt; but, having the two authorities named to contend against, his protests were hardly noticed. He was sustained, however, by Fischer, who had found, independently of Pratt, that both the base lines and the area of this Indian survey were of such an extent as to require the use of too great a number of coefficients. Thus he was enabled to show that the deviation of the lead caused by the Himalaya Mountains was concealed by too great a possible error; for which error the great distance to the sea coast is principally responsible. He calculated the least possible deviation caused by the Himalaya Mountains at Kaliana, the northernmost station of India (nearest to the range) at not less than 35 seconds.

The explanation for the supposed want of such a deviation which Sir G. Airy proposed has been noticed in the paragraph contained in No. 13 of the SCIENTIFIC AMERICAN, viz.: That the Himalaya Mountains reach down into the denser liquid interior, and there displace a certain amount of this liquid, so that their own attractive force is thereby lessened. They are floating, as it were, on, or rather partially in, the liquid interior of the earth.

This hypothesis is certainly untenable, since the two assumptions on which it is based are themselves untenable. Not only have Fischer and Pratt shown that the probable error contained in the results of the surveys is large enough to offset the possible variation of the direction of gravity—the liquid interior itself, as has been shown, is becoming more and more problematical in the light of recent developments.

As to the deviation which the direction of gravity is subject to on oceans near the continents which form their coast, this cannot be expected to be determined by direct observations, for the reason that, as has been alluded to before, the surface of the oceans themselves is affected by this attraction. Fischer's careful and extensive calculations have led him to assume a deviation of from seventy to eighty seconds as an average, while at certain points it may even come near to 100 seconds, as, for instance, on the western coast of South America, with its steep coast line and its high plateaux and mountain ranges, averaging from 12,000 to 14,000 feet.

The *variations of intensity* to which *gravity* is subject are of very great importance, in as far as a correct appreciation of their causes and their extent will be the only means to solve definitely the problem of the true figure of the earth. And the means to do this are pendulum observations, since the rate of oscillations depends on the degree of intensity with which gravity acts on the pendulum in different localities.

1. As to *the distance from the earth's center*, the rate of pendulum oscillations diminishes with its increase and increases with its diminution. The same pendulum will make an increasing number of oscillations when observed on various points of the same meridian in the direction from the equator toward the pole. The polar, being about 26½ miles less than the equatorial diameter, a pendulum vibrating seconds at the equator would make about thirteen more vibrations in a day at either pole, being nearer to the center of gravity by this distance. Theoretically speaking, the number of oscillations of the same pendulum ought to be the same on all stations occupying the same circle of latitude, provided, of course, they had the same altitude. For, if we carry the plummet from the foot to the summit of a mountain, we increase its distance from the center of gravity, and thereby diminish the rate of vibrations. And to every 119 meters in a vertical direction corresponds one vibration of the pendulum.

To the same cause must be attributed the well-known fact that the intensity of gravity above the oceans is greater than it is on the land, even at the sea coast. It is very difficult to understand how a man of the great and extensive knowledge which M. Faye possesses could try in earnest to explain this phenomenon in the way he did, *i.e.*, that "under the oceans the globe cools more rapidly and to a greater depth than beneath the surface of the continents." As early as 1842, M. Saigey, a countryman of the great Academician, has, in his "*Petite Physique du Globe,*" given the true explanation. The continents exert the same influence by the action of their attraction on the waters of the ocean that great mountain ranges have on the plummet. By this attraction the level of the sea, at the coast of the great continents, is raised to a much greater height than it occupies in mid-ocean.

The same phenomenon has also been described and its extent calculated by Stokes and Fischer. While Saigey had assumed the probable height of the coast-line above the level of the Atlantic in mid-ocean to be about thirty-six meters, Fischer has given between 600 meters and 900 meters as the probable elevation of the coast line above the sea-level in mid-ocean, an estimate which is not at all too high. For the rate of pendulum oscillations obtaining on isolated islands in mid-ocean is a sure indication of the real extent of this lowering of the general level of the oceans to a degree heretofore unsuspected; this is evident from the following table, which gives the daily increase in the rate of oscillations of a pendulum vibrating seconds at London:

Bonin Islands	+14·2
Ualan	+12·6
St. Helena	+10·3
Isle de France	+ 9·9 + 7·0
Fernando de Noronha	+ 9·4
Guam	+ 8·7
Marian Islands	+ 6·8
Sandwich Islands	+ 5·2
Pulo Gaunsah Lout	+ 5·0

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* Friedrich Mohr, *Geschichte der Erde.* 2 Aufl., Bonn, 1875, p. 300.

† Mohr, l. c.

‡ Herm Klein, Die Fortschritte auf dem Gebiete der Geologie, No. 2, 1874–1875, p. 57.

* Fr. Mohr, *Geschichte der Erde*; 2d Ed, M. Cohen & S., Bonn, 1875. On page 425 there is a chapter "*On the Oblateness of the Earth,*" from which a few passages may be quoted: "It does not suffice to explain the constancy of the earth's oblate figure simply by the assumption of its original fluidity; it is the figure of the great oceans which preserves it. Whatever shape the earth may have had formerly, the existence of both its oceans and its rotation must at last give it the figure of *an oblate spheroid*. Even if we conceive the earth to have had originally a shape resembling, *e. g.*, a *tetrahedron*, the oceans would have covered its triangular surfaces in the form of flat arcs. . . . The angles would have projected for miles into the atmosphere, and been subjected to tremendously efficient glacial action. With this rasping off of these angular projections, the sea would have more and more retreated, and since glacial action can only take place above the level of the sea, it is evident that the earth's figure would gradually have assumed a spheroidal form, by its rotation somewhat oblate. The constant destruction by glacial action, therefore, tends to preserve this figure of an oblate spheroid much more correctly and efficiently than its original fluidity could have done."

† *Cambridge Philosophical Transactions*, VIII., 1849, p. 672.

‡ In the surveys and triangulations for this purpose the lead and line, as well as the leveling instrument and the theodolite, are influenced by the variations of the direction of terrestrial gravity, as will be seen further on.

§ Variations of density, such as Faye and Airy assumed to be caused by unequal cooling of the deeper strata.

‖ *Sc.*, the border (coast) of.—G. W. R.

These figures show that Fischer's estimates are rather too small than too great.

The latter supposition is strengthened by a glance at the influence of the causes mentioned under the second head, viz.: the circumstance whether the medium intervening between surface and center is partially liquid, and to what extent. For, the deeper the ocean, the more must the attraction of gravity by the upper strata be lessened as against shallow water, not to speak of dry land itself.

As is well known, Mr. Siemens, the eminent London engineer, has constructed an instrument, the *bathometer*, which enables those on board of a ship to read from its index the depth of the ocean beneath them. It consists of a highly sensitive steel spring, to which a heavy piece of metal is attached; the changes in weight which the latter is subject to in consequence of the variations of attractive force (the deeper the ocean, the smaller the latter, and *vice versa*), are registered on a scale by the indicator that is in connection with the steel spring. This instrument will be in future, when the true figure of the earth shall be the subject for which numerous pendulum observations on various points of the globe shall be systematically instituted, of considerable value, because it is an admirable substitute, and the only one known at this time, for such observations as these are infeasible on ship-board. It would, of course, be necessary to apply an important correction, in as far as the level of the great oceans is nearer to the center of gravity by many thousand feet, a circumstance which influences results in a directly opposite way. The coefficient could, however, be ascertained in two ways, viz.:

1. By comparing results obtained over great depths, measured previously by lead and line; and

2. By comparing results obtained on isolated isles in mid-ocean with those obtaining over great depths in its nearest neighborhood.

The third influence, the intensity of centrifugal force, is one which for our purpose deserves only passing mention. It is a factor which allows of accurate computation by theoretical calculations. Having on the equator about as great an effect on the intensity of gravity, as has the greater distance from the center of gravity in this region, it diminishes gradually toward the poles, where its action ceases entirely.

The true figure of the earth is, therefore, a physical problem which may be solved with tolerable accuracy; but it is not by geodetic work, however, that the most reliable solution will be arrived at, but by pendulum observations, assisted by experiments with the Siemens bathometer. And it is, indeed, very fortunate that this should be so, since the latter method is much more simple and much less expensive. A pendulum, vibrating seconds at London, Washington, Paris, or any other primary station, being taken as the standard, principal stations on large plateaux, near high mountain ranges, at the sea coast, and in the midst of great oceans (on isolated islands), will give the true figure of the earth by showing its deviation from its theoretical figure of a revolving ellipsoid. For it is not the sea coast that should be made the basis of these observations, but the surface of the great oceans, *i. e.*, their distance from the earth's center.

Of course geodetic work in the way of triangulations should assist this work of systematic pendulum observations, since they are a valuable controlling adjuvant; and as Dr. Hann suggests, in an excellent paper on the subject, such surveys should be begun at once in our Southern States. They would be especially adapted to the purpose, forming as they do a direct counterpart to the great East Indian triangulation, which has principally given rise to and sustained the view of Clark, that the earth is an ellipsoid with three different axes.

It is certainly an object worthy of the earliest consideration by the officers of our Coast Survey and our Signal Service; and the United States, by instigating these final observations to determine the true figure of the earth, would add another leaf to the glorious history of their scientific discoveries.

IN WHAT WAY DOES THE SUN GIVE LIGHT AND HEAT?

ALL science should harmonize and all deductions from scientific facts should agree. A single proved scientific fact is of more value than a thousand theories, and pleasing structures builded on partially understood laws must be remorselessly sacrificed to truth. The inverted pyramids of argument which have been set up on the theory that the sun is a vast heat and light radiating body, are not all logical deductions from scientific facts, and in regarding them one is disposed to cry, Give us light, more light!

We do not purpose to prove anything, but simply to call attention to some facts which tend to show that the idea of the sun giving light and heat directly is neither a reasonable nor a logical deduction from facts.

That the sun is the source of heat, or rather, so to speak, the heat motor of the solar system, is evidently true. Further, it is, as Tyndall says, the source of all activity upon the earth, and this being so, the question arises, By what subtle influence does it work?

So far as we know light and heat are the manifestations of the sun's power. The argument that we receive these by direct radiation from the sun involves many difficulties and contradicts much of what we know as to the workings of nature's laws. The vast waste of power which that method involves is opposed to our reason and to the simplicity which marks nature's laws.

Take, first, certain propositions, and then see how far they are sustained by observed facts:

1. Heat is static energy.
2. Electricity is dynamic energy.
3. Heat is a product of electricity.
4. There is no energy without electric action.
5. All energy is from the sun.
6. The sun's energy is solely electrical.
7. All forms of light and heat are resultants of electrical action.

It has been well remarked that one of the principal things man has to contend with is combustion. To be more accurate we should say that the principal business of life is the regulation and control of combustion. We know more of combustion then people of ancient times, but as science never halts, we may suppose it possible to learn more of even simple phenomena. To the scientist combustion means the change that is constantly taking place in matter with more or less rapidity, of which fire is but a single phase, the one most noticeable to our senses.

Looking at combustion in the wider sense, we are taught, 1st, that by the combustion of materials belonging to what is termed the vegetable kingdom (which strictly speaking embraces only materials that are produced and reproduced upon the earth by the sun's action) the product is heat, intense in proportion to rapidity of combustion, and such combustion being simply a chemical change of the constituent elements of non-metallic bodies, the product of heat may be regarded as a manifestation of the energy involved in the change.

2d. The product or manifestation of energy in the combustion of bodies consisting wholly or partly of metallic elements is electricity.

Stated in another form, heat is the product of combustion of materials which are non-conductors of heat and electricity. Electricity is the product of combustion of materials which are conductors.

3d. Heat is also produced by the arrest or retardation of energy or force, in any form, especially of the electric current.

4th. Electricity is produced when heat is converted to magnetism, as in the frictional and other electric machines, more directly in thermo-electric machines.

Electricity may, then, be said to be a mode of motion, or dynamic energy, and by parity of reasoning heat is static energy.

Something may also be learned in this same direction by comparing the known effects of the electric current with the effects of the sun's energy. For a simple example take electrical decomposition, and its effects in the production of colors.

In automatic telegraphy, wherein the currents are passed through paper saturated with chemical solutions, iodide of starch, for instance, the dots and dashes are produced by decomposition of the chemicals, the color varying with the materials used for saturating the paper. This may be regarded as a direct application of electricity. Indirectly and more slowly the same effect is produced by the electric light, and in photography the equivalent action of the electric light when used in place of sunlight is well known. Sunlight produces the same effects. The leaves of the trees and all vegetation take their hues from the sunlight action.

Chemical analysis of leaves proves the existence of iodides and other chemical substances that are decomposed by sunlight and color produced. We suggest here an experiment of growing plants out of sunlight, and subjecting them during growth to weak electric currents and the electric light. Thrifty full colored plants can, we believe, be propagated in that manner.

A further comparison of sunlight and the electric light is instructive. Compare the electric arc out of vacuum, intense in brilliancy and accompanied with intense heat, with the soft diffused light produced with Geissler tubes, the former limited in length, while in the latter, the current, relieved from air, seems to expand like a compressed fluid relieved from its confines. Since the presence or absence of air makes such a difference the question arises, What function does it perform? and does it not perform a similar function in relation to the energy given off by the sun? We know that as we ascend to thin atmospheres the air grows colder. Why should that be? The reasons usually given are not satisfactory; it is far more logical to assume that if we pass beyond our atmosphere we shall find an entire absence of heat and light.

Again, light and heat are said to travel to the earth from the sun. It is more reasonable to our minds to say that the sun's energy travels to the earth and is changed to light and heat by the earth's atmosphere, or rather changes the earth's atmosphere to light and heat. Air is a mixture of two elements. To unite them chemically requires intense heat. Electricity has the power to directly unite the elements necessary to form nitric acid. Is it any violation of known facts to assume that the sun's energy unites the elements of the air, and produces light and heat by production of compounds such as nitrous anhydride and ozone, both of which gases we know so little about, and which are closely connected with electrical phenomena?

As this article is intended only to be suggestive, enough has been said to stimulate thought and experiment. We add only this final thought, which embraces all. May we not see clearly, sooner or later, that the sun's energy is simply electricity; that it is a vast battery of minerals in a state of combustion, and that its vapors are the gases thrown off by every electric battery? Then we shall understand better than ever before the grand simplicity of universal laws.

The strongest arguments against any of the propositions stated above will be found in the usual deductions of astronomical science. Our propositions, if true, contradict much that is generally accepted as truth, but in that case so much the worse for astronomy. W.

THE NEBULA IN ORION.

By PROFESSOR HENRY DRAPER.

THE gaseous nebulæ are bodies of interest because they may be regarded as representing an early stage in the genesis of stellar or solar systems. Matter appears to exist in them in a simple form, as indicated by their simple spectrum of three or four lines. It is desirable, therefore, to ascertain what changes occur in the nebulæ, and determine, if possible, the laws regulating their internal movements. Drawings by hand have been made of some of the nebulæ, and especially of the nebula in Orion, for upwards of 200 years. But drawings are open to the objection that fancy or bias may distort the picture, and it is, therefore, difficult to depend on the result, and to compare the drawing of one man with that of another. To apply photography to depicting the nebulæ is difficult, because these bodies are very faint, and of course, owing to the earth's motion and other causes, they seem not to be at rest. They require a large telescope of special construction, and it must be driven by clock-work with the greatest precision. All such difficulties as those arising from refraction, flexure of the telescope tube, slip of loose bearings, atmospheric tremor, wind, irregularities of clock-work, foggy or yellow state of the air, have to be encountered. The photographic exposure needed is nearly an hour, and a slip or movement of a very small fraction of an inch is easily seen in the photograph when it is subjected to a magnifier.

The means I have used to obtain the picture are as follows: A triple achromatic objective of 11 inches aperture, made by Clark & Sons, according to the plan of Mr. Rutherfurd, for correcting the rays especially for photography. This telescope is mounted on an equatorial stand and driven by a clock that I made myself. The photographic plates are gelatino-bromide, and are about eight times as sensitive as the wet collodion formerly employed.

As to the picture itself the nebula is very distinct in its bright portions. The stars of the *Trapezium* and some others are so greatly over exposed that under the magnifying power employed they assume a large size, partly from atmospheric tremor and partly from other causes. It is probable that much more of the nebula will be obtained in pictures taken in the clear winter weather. This photograph was made at the end of September, when there was some fog in the air; but nevertheless, the original shows traces of the outlying streamers seen in the drawings of other observers. A series of photographs taken at various times of the winter season and in different years will give us the means of determining with some precision what changes, if any, are taking place in this body.—*Proceedings National Academy of Science, New York*, 1880.

"TELLING THE TIME."

A lecture by Prof. WALDO, of the Winchester Observatory of Yale College.

PROFESSOR WALDO, astronomer in charge of the Horological Bureau of Winchester Observatory at Yale College, recently delivered the sixth lecture of the annual course to mechanics, given by the Sheffield Scientific School of New Haven. Many of the college professors were present with their families, and the large hall was filled with an attentive audience. Prof. Waldo was surrounded by considerable scientific apparatus, among others, the necessary appliances for exhibiting upon a screen the various objects his lecture was intended to illustrate. The display upon the screen of the movements of a watch in motion, with the motion plainly apparent; the dropping of the time ball, and the firing of the noon gun—in this case a pistol—both by electricity, with dramatic pauses of expectancy, and various other episodes, were highly interesting features of the evening's excellent entertainment.

The subject of the lecture was "Telling Time," and we present the following synopsis of the Professor's remarks:

I feel very much as though this occasion had been contrived as a polite means of calling the Observatory people to account for the radical idea of obliging a literary and a university town to keep a strict regard for time. Exact time belongs to railroads, to express companies, to science. The generous life of literary effort forbids the cramping influences of a day with an arbitrary twelve o'clock. The soul of heart rebels against a clock which does not err, or a watch which counts the eighty-six thousand four hundred seconds of a day with precision. The gentle and persuasive owners of those wonderful pieces of ornamentation and bad time-keeping qualities—ladies' watches—feel aggrieved at any precision which their little jewels cannot comprehend. It is to show you how excellent are our motives, how precise our results, how great are the benefits, that we shall address ourselves this evening.

The time-balls dropped from their masts at Deal, at Cape Town, and from the magnificent head of Sydney Harbor, are perhaps familiar to you, and it will be to you not an uninstructive thought that even in distant British colonies there exists this thoughtful attention to the needs of every ship, domestic or foreign, which enters the port. You will reflect, doubtless, that until within quite recently this kindness has not been reciprocated in one American seaport. And you will be gratified to know that the Western Union Telegraph Company now display, at five minutes of twelve, a ball at the top of a mast placed on the highest pinnacle of their Broadway building in New York; and that precisely at noon, as indicated from the U. S. Naval Observatory, Washington, it falls from its conspicuous position. The query of the Cambridge poet rises on our lips—

> "Well, neighbor, tell us wut's turned up that's new!
> You're younger'n I be—nigher Boston tu;
> An' down to Boston, ef you take their showin',
> Wut they don't know ain't hardly wuth the knowin',
> There's suthin' goin' on I know."

That the Harvard Observatory drops its signal of Boston noon, and that there is now an effort to have time-balls at the important ports of our coast. I have mentioned the time-ball first, because it has secured for itself a wide recognition as the simplest way of announcing an arbitrary instant of time. But like the newspaper dropped at the door, or the water which flows upon turning the faucet, the simple result attained in the dropping of a time-ball is the outgrowth of the most refined principles of mechanism, and is the product of skillful assiduity of the astronomer. It is our province now to ask these questions—"Where do we get and how do we keep our time?" These questions come with force at the moment when we stand looking alternately at the face of our watch and the rear platform of a departing train; or when the Gold Stock Exchange closes one minute before we thought it would; or when some majestic steamer wrecks in a fog on our coast because her chronometers are at fault.

But we are chiefly to concern ourselves to-night with the instruments used to fix observatories for determining time. You are aware that the stars are located on the celestial sphere by a system of co-ordinates, closely resembling our terrestial ones of latitude and longitude. These are called declination and right ascension. Now declination the astronomer measures with carefully graduated circles, but in measuring right ascension, the astronomer fixes his instrument in one plane, and notes by his clock how long after one star passes this plane another follows it. But he must be able to measure this interval of time with a degree of accuracy which corresponds to the accuracy reached with the graduated circle. Hence the Observatory continues to be recognized critic of the performances of time-pieces, for nowhere else in the arts or sciences is the exact measurement of considerable intervals of time of such vital importance. The instrument almost universally used in determining the time is the astronomical transit instrument. We have before us to-night a very beautiful specimen of this instrument, presented to the college by Dr. Hillhouse. You notice that it has but one motion, simply round this axis which points east and west, and makes a right angle with the telescope tube. Now, as I take hold of the telescope, you see the telescope only moves from the north to the south, that is, in the meridian. If we suppose this axis to be perfectly horizontal—and this delicate level rests on its pivot and will tell us if it is not so—I think you will readily see that the astronomer has only to point the instrument so that it will have the same altitude as a star approaching the meridian, in order to have that star visible in the telescope as it crosses it. Now, if we imagine the star to be exactly in the center of the field of view of the telescope, to-night, and if we do not move the telescope, to-morrow night at about this time the same star will reappear, and the interval between its two successive appearances is one sidereal day. The first objection the astronomer has to observing the sun

for time, is that it is difficult to get enough stars in the day time to determine the position of the instrument, and another objection is found in the greater uncertainty attending the transit of the sun's limbs, which I think we can see on the screen. We have here a beautiful photograph taken from the sun directly, and for which we are indebted to the skill of Lewis M. Rutherfurd, Esq. You will notice that the rounded limb of the sun cannot be so nicely bisected as can the image of this star which follows afterward.

Let us now examine the method of noting the transit of a star across a wire. If I take this chronometer or that clock, I can count the beats as I sit with my eye to the telescope; and as the star crosses each wire; I can note the second and the fraction of a second; and a skillful observer will only on rare occasions estimate this fraction a fifth of a second in error. It is better, however, to lessen the errors which depend upon the personality of the observer, such as his observing too fast or too slow, and to economize the time of writing down the observations, to record them automatically, by means of the chonograph, an instrument first used in this connection by an American astronomer. We have a beautiful one before us, and you see it consists of a metallic cylinder around which a sheet of paper is coiled, which is revolved uniformly by clock work. A fountain pen rests upon the surface of the paper, and as the cylinder revolves the pen draws a line upon it. Now, if you conceive that this cylinder be slowly moved along at the same time it revolves, you will understand that the pen never marks over the same part of the paper. Suppose that the cylinder rotates just once in sixty seconds, and suppose that I cause this clock, by means of an electric current, to slightly move the pen at the beginning of each second; this will cause a slight notch in the line, which registers upon the paper the beginning of each second; and if we omit the slight notch which would be made by the fifty-ninth second we can thus register the beginning of each minute. The telegraph key which I hold in my hand is in the same electric circuit with the clock and chronograph, and as this star is passing over the screen I can register its transit upon the chronograph by simply causing the pen to make a notch in the line by breaking the electric circuit. We have put a telegraphic sounder in the same circuit, so that I think you will be able to hear the beats of the clock quite to the other end of the hall. There comes one star, and as it crosses each wire you will hear the familiar telegraph tick which tells us that we have made a slight notch on the chronograph which records the star's transit. Now, suppose that this slight notch we afterward find occurs six-tenths of the way between the thirtieth and thirty-first second. Then we know that the star's transit occurred at thirty-one seconds and six-tenths of a second of a particular minute. After an evening's observation, the sheet is removed from the cylinder, labeled, and filed away with the records of the Observatory.

Having obtained the error of our time-piece to within a twentieth of a single second, the next question is, How shall we keep the time-piece so that it will have the same error to-morrow night that it has to-night; or failing in this, how shall we preserve the same relation between the errors on consecutive nights? In other words, how shall we know that the time-piece gains or loses regularly? This leads us to speak of the way clocks and watches keep the time from day to day. You all know that the test of the performance of any time-piece is found in noting the regularity with which it gains or loses. Thus a clock which gained ten seconds a day might be a very much better one than another which gained and lost, alternately, ten seconds a day. Though at the end of the week the better clock would be a minute more in error than the second one. The point I wish to illustrate is that with an accurate time-piece we can always predict what its error will be, for some days in advance, while with a poor time-piece we can form no idea from the determination of its error on two nights, what it will be on a third one. Now it is to the elimination of the sources of error in clocks and watches that the attention of the artisan is directed; and the practical form which successive improvements take is in more perfectly protecting our time-pieces from the effects of temperature changes, and from those resulting from variations of friction in the movement. In the clock we endeavor to guard against the effects of temperature on the pendulum by uniting two metals in such a way that one expands upward while the other expands downward, and they are so adjusted that the center of the pendulum stays very nearly in the same position. Now although the clock is the most perfect time-piece we have, yet it is still liable to the theoretical objection that its pendulum swings in a circular instead of a cycloidal arc. You will be interested to know that the finest clocks for astronomer's uses are so sensitive to external influences that if the barometer were to change an inch in height, it would cause a variation in the clock's rate of about a quarter of a second per day; and I might mention that in some large observatories the standard clock is kept in a cellar vault to avoid changes of temperature and in a hermetically sealed glass case from which the air has been partially exhausted. At the Harvard Observatory the clock which distributes the signals to Boston and along the lines of the railroads is placed in the cellar inside of a thick walled room which has a floor of sheet lead, its walls filled with dry sand and its door joints with felt. Our own clocks, used in the distribution of the standard time which is soon, we hope, to become the recognized standard over a large area of western New England and the Eastern Middle States, are protected in a similar manner. And it is a matter of considerable interest to many of you to know how well a clock can be made to run under these favorable circumstances. I will give you the variations of the mean monthly rates of the clock Howard 191 which is now sending its beats over the city.

1879.	March,	rate varied	lost 0·16	second.
	April,	"	" 0·08	"
	May,	"	" 0·13	"
	June,	"	" 0·08	"
	July.	"	gain 0·20	"
	August,	"	" 0·22	"
	September,	"	lost 0·02	"
	October,	"	" 0·08	"

And you will observe that these variations of rate are expressed in hundredths of a second of time.

Let us examine the parts of a watch as we have them upon the screen. (Here a watch movement in full motion was projected upon the screen, and Mr. Waldo explained the various parts.) We are indebted to the Mechanical Superintendent of the Waltham watch factory for this very interesting exhibition of a watch in motion, projected against the screen. The chronometer, either marine or pocket, is superior to any other form of watch made, if we consider only its performance when it is kept in one position; but it is inferior to almost any other well-made form of watch if it is constantly exposed to the jar of the person in walking or running. The precision obtained in the very finest of pocket chronometers is surprising; thus, the mean daily variations in the rates of the two best chronometers exhibited by the American Watch Company at the Philadelphia Centennial Exposition were twelve and fourteen one-hundredths of a second, respectively. Quoting from a recent report of the Neufchatel Observatory on the annual competition of Swiss chronometers for prizes awarded yearly by the observatory, the two best pocket chronometers had an average daily variation in their rates of thirteen and seventeen one-hundredths of a second respectively. These rates would not discredit an astronomical clock. We have now considered the methods of determining exact time, some of the precautions necessary to keep it, and our last division of the subject will be how to distribute it without sensible error. We have been talking, in describing star transits, of sidereal or star time, and since the stars rise four minutes earlier every day, the sidereal day is four minutes shorter than our common day. Now, it is common or mean time which we wish to distribute, so first we must convert the sidereal time into mean time.

Let us cause the sidereal clock which is beating in the room beneath us to repeat these beats upon the telegraph sounders about the room. You notice the ticks are now heard each second until we get to the fifty-ninth, which is omitted to tell us the beginning of the next minute by its absence. But the sidereal time is to be transferred to mean time before it is ready to go out over the telegraph lines to regulate our affairs in everyday life. If we attempt to compare the sidereal clock directly with the mean time clock, we shall be liable to the error of estimating fractions of a second by the ear; but if we remember that the sidereal clock gains on the mean time clock a whole second in every six minutes, we can wait until the sidereal clock beats exactly with the mean time clock, and then by noting the time of each clock we have a very exact means of comparing the clocks. Here we have the familiar beats of the mean time standard, beating every two seconds except at the beginning of the minute. You will notice, by careful listening, that the sidereal beats are gradually catching up with the mean time beats, and they are now beating exactly together. Let us note the times by each clock. Now, you will see by the short calculation I have just made to reduce our sidereal time to the true mean time of the standard we adopt, that our clock is now eight hundredths of a second slow; an amount so small that I hope none of our good friends the jewelers and railroads will take us to task about it. We shall reduce this error to nothing by altering the clock. Thus we have a mean time clock set perfectly to mean time, and by means of an electric circuit ready automatically distributes its beats over as long a circuit as we choose. We have about the hall a miniature telegraph line with telegraphic instruments at two or three points, which, if you please, we will imagine to be Hartford, Springfield and New York. We have only to switch the clock into this circuit, with some precaution to avoid the strong battery power used, and you hear immediately the beats of the clock registering themselves at each station. In order to distinguish the beginning of the minute the last five seconds are struck. In addition to this omission in our Observatory system, the clock omits twenty seconds immediately preceding each five minutes. For a single signal it is customary to resort to the time-ball, or the time given, both of which require considerable mechanism which shall act automatically from the clock. I think we can illustrate the first of these methods by means of the simple ball you see suspended before you. It should be electrically released the instant the second hand of the clock reaches the beginning of the minute. In regard to the gun the Astronomer Royal for Scotland observes: "You would do well, if you can, to pull the trigger of a time-gun, for there are no means under heaven equal to a gun for speaking to human nature and obliging it to attend."

The gun we have extemporized will be discharged at the commencement of the next minute. I cannot speak to you to-night of the many other methods communicating the time by means of electric clocks or the display of the time regulated from the Observatory. Nor can we speak of the plans of our Observatory for the encouragement of a higher excellence in the great and growing horological industries of our country. We have left untouched great divisions in the art of measuring and disseminating time, but a regard for the subject of my lecture reminds me that I must close. Much of the pleasure in the experiments of the evening is due to the kindness of Prof. Lyman in arranging some of our experiments, and to Mr. William Beebe.

THE THEATER OF DIONYSUS AT ATHENS.

AT the first of a recent series of meetings open to the public under the auspices of the Harvard Philological Society, at Sever Hall, Cambridge, Professor John Williams White gave a descriptive sketch, says the Boston *Advertiser*, enlivened by the freshness that can come from a personal visit of the scene, of the Theater of Dionysus at Athens, and touched briefly on the development and representation of the ancient Greek drama. In considering the ancient Greek theater, said Mr. White, the theater of to-day furnishes a contrast, and not a parallel. We go to the theater at night and remain three hours; the Greek was in his from dawn to dark. The modern theater is open the greater part of the year; that at Athens for three days only in the spring. That temple of Thespis, the Boston Theater, will hold at most 3,000 people, and, like all the rest, is a stuffy pit saved from darkness only by the modern invention of gas; at Athens 30,000 spectators sat together under an open sky, in a transparent atmosphere, with the blue sweep of the sea in clear view, and the nibs of the Peloponnesus on the distant horizon. During the three days of the representations at the theater, Athens was entirely given up to a season of holiday pleasure and excitement, the festival at its height furnishing, perhaps, a parallel to a modern carnival in some Italian city. In building the Theater of Dionysus, the Greeks availed themselves of the advantages offered by a natural situation. On the southeast side of the Acropolis was the necessary steep-sloping hillside, and there, too, by a happy circumstance, was a spot which tradition had marked as sacred to Dionysus. Out of the hillside were hollowed, in semicircular form, the seats of the spectators; at its foot lay the orchestra, and beyond the orchestra the palatial stage building. The utmost row of seats at the top of the hillside had an actual elevation of more than 100 feet above the floor of the orchestra; and the seats themselves, concentering at the orchestra, are divided by stairways into 13 wedge-shaped figures, the distance up the hill from the first to the last row measuring nearly 300 feet.

Of the stage building, which was 250 feet long and two stories high, the greater part lay 13 feet further back than the rest, thus making two wings, one on either side. Here the stage was built of wood, 90 feet in length, and the back wall, rising from the stage floor to the top of the first story of the palace, was called the scene. These distances in the Greek theater were so enormous that, in order to give the actor the appearance of greater height and size, he wore in tragedy buskins with soles of great thickness, padded his limbs, and had a colossal mask projecting above his head. After the development of the drama had subordinated the chorus to the dialogue, the number of actors was never increased beyond three, and their dresses, instead of being adapted to the characters, were usually the ordinary costume, in brilliant colors, such as was worn by all citizens in festival time. Though the chorus came in time to be subordinated to the actors, it remained always an essential part of the Greek play. The orchestra (literally "dancing place," and here carrying its literal signification) where the chorus performed its work, had a diameter of about ninety feet, or nearly as great as the diameter of the whole of the Sanders Theater; and at its center stood the temple of the god. What was the music the chorus sang, and what were their dances? These are pertinent questions; but questions that cannot be answered. Though the words of the chorus remain, the rhythmical movement and melody are lost beyond recovery. And in trying to reproduce these in the proposed presentation of the "Œdipus Tyrannus," effort will be directed to the spirit rather than the form of the music. The audience, as is now well proven, comprised women as well as men and slaves. In the front row of seats were the priests and the magistrates; behind these the senators and distinguished strangers; next behind a pushing but good-natured crowd, whose appearance and actions remind one nowadays of Harvard undergraduates. The crowd began to pour into the place early in the morning, all bringing luncheon with them to eat between the plays. A Greek audience was enthusiastic and impulsive. An unusually good piece of acting in tragedy would cause the people to rise, to dance, shout, and cast aside their garments; and if, perchance, one's acting was *very* bad, they would hiss, and even take him to task by beating him. The Greeks aimed at realism, but not as we do. We should not be satisfied if never allowed to see a man murdered in plain sight. Cæsar is fairly riddled by the daggers of the conspirators, and we take no offense. The Greeks, on the other hand, did not allow bloodshed on the stage. *Jocasta*, in the "Œdipus Tyrannus," rushes *within* to her suicide, and it is there that *Œdipus* puts out his eyes.

ARCHAIC GREEK ART.

THE new Professor of Archæology at University College, London, Mr. C. T. Newton, C.B., D.C.L., M.A., Keeper of the Greek and Roman Antiquities in the British Museum, wound up his inaugural course of lectures on "Archaic Greek Art," with an extra one on "The Later Period of Archaic Greek Sculpture." The lecture-room was crowded with students and visitors. The five previous lectures treated of the earlier stages of Greek art from its rude beginnings at Mycenæ to the period when great advances had been made in the casting of bronze, when marble had come into more general use as the material of sculpture, and when we first found Greek inscriptions on works of art. In these five lectures Greek art was traced to as late as about B.C. 520. The later archaic period might be conceived as extending over about the half century from B.C. 520 to about B.C. 470, soon after which date Phidias flourished. This period of fifty years was pregnant with great historical revolutions, the ultimate results of which were to establish the pre-eminence of Hellenic civilization and secure the national independence. Within this period fell the expulsion of the Pisistratidæ from Athens, the defeat of the Carthaginians by Gelon, and his rule and that of his brother Hiero at Syracuse; the revolt of the Ionians from Persia and their final submission after the fall of Miletus; the successive victories of the Greeks over the Persians at Marathon, Salamis, Platæa. In the same age tragedy under Phrynichus and Æschylus was developed at Athens, Pindar flourished, and Herodotus was born. The progress of art during the same period was commensurate with these great changes. One principal cause of this was the growing importance of the great Agonistic festivals, especially of that of Olympia. It became the custom for victorious athletes or winners of the chariot-race or horse-race to dedicate statues and groups in commemoration of their victory either at Olympia or in their native cities. Bronze was the principal material used, and thus the artists gradually learned how to represent groups in violent action, while their observation of nature was sharpened by the study of living forms. Ageladas, an Argive sculptor, who was the teacher of Phidias, made several of these groups. Onatas, of Ægina, was another celebrated sculptor of this period. He made at Olympia a group representing the Greek heroes casting lots who should fight with Hector, and other groups and statues at Olympia. Three artists of this period—Canachus, Callon, Calamis—are associated in the two well known passages of Cicero and Quintilian, from which we gather that in the judgment of Roman critics Canachus and Callon were harder in style than Calamis and less true to nature. The most notable work from the Attic school in this period was the group of Harmodius and Aristogiton by Critius and Nesiotes, of which we may form some notion from a group in marble extant at Naples, from an Athenian coin, and from a vase. Calamis, who was an Athenian artist, excelled in the representation of horses, and commemorated the Olympic victories of Hiero by bronze groups at Olympia. Pythagoras of Rhegium was another sculptor who made statues of Olympic victors, and who is distinguished as having made considerable advance toward the more correct rendering of nature, especially in the representation of the surface of the body with its veins and muscles. The temples built in this period further promoted the progress of sculpture by the decorations they required in the metopes and pediments. Thus artists were exercised in the composition of complicated groups of figures in the round. The lecturer then described the various drawings which were exhibited: Two metopes from temples at Selinus, in Sicily (the earlier might date from as early as B.C. 600, the other probably as late as B.C. 470); one side of the frieze of the Harpy tomb; casts of two sphinxes from Xanthus; a bronze representing the Apollo of Miletus; the western pediment of the temple of Athene, at Ægina; a coin of Syracuse of the time of Gelon I.; a terra-cotta figure from Camirus, in Rhodes; the warrior on an Athenian stele, by Aristocles; a seated figure of Athene, from Athens.—*London Times.*

EELS.*

(Anguilla acutirostis.)

PRESENT KNOWLEDGE OF THE EEL.

THE eel has long figured as one of the most mysterious of animals. For 2,200 years it has been the object of more or less discussion. Aristotle maintained that it "is born of worms produced by mud; Pliny, that it rubs itself against rocks, from the fragments of which young eels are born." Thus from the fourth century before Christ, to the year 1873, the eel has been the afflicted object of all manner of absurd theories from a long list of investigators. In the year mentioned, Dr. Syrski read his observations on the Italian eel, *A. vulgaris*, before the Academy of Natural Sciences at Triest. Investigations were begun on the 29th of November, 1873, and the second eel opened showed the generative organs of the male. This was the first male eel discovered, the announcement of which was sent to the Academy of Sciences at Vienna. The same investigator continued his observations, rectified many mistakes concerning the organs of reproduction in the female, and gave much additional information. Later on Prof. Packard "detected the mother cells, and Mr. Kingsley observed moving, active spermatozoa." The knowledge of the breeding grounds of the eel was bound up in the following expression, taken from page 447 of Packard's "Zoology:" "It is probable that the eel descends rivers in October and November, spawning in autumn and early winter at the mouth of rivers and in harbors and estuaries in shallow water." This sentence really expresses all that was conjectured or known about the breeding grounds of the eel up to within a few short months. About the time I was making my observations along the Oswego River, a double article appeared in the New York *Times*, the first producing evidence confirmatory to the theory of breeding in the mouths of rivers, and the other, by John G. Sawyer, showing that eels may breed in any soft mud of flowing water. This article was reprinted in SUPPLEMENT, 239, of the SCIENTIFIC AMERICAN. My investigations, I think will show how near the truth the double *Times* article was.

ORIGIN OF THE OSWEGO RIVER INDUSTRY.

The eel industries of the Oswego River are nearly ten decades old. Toward the close of the 18th century, one John Van Buren erected a log-hut in the woods along the Oswego River, then regarded as the extreme western verge of American civilization. Following on his track people began to settle around him, making the question of food supply the one most prominent to the hardy pioneers. The river rolled grandly by uninterrupted by its present dams or the hum of gigantic industries. Its waters were stocked with fish, among which common eels, then extraordinarily plenty, attracted the speculative attention of John Van Buren. He accordingly began a fishery and found a ready market among his fellow neighbors. Thus was begun an industry which has since assumed sufficient proportions to furnish profitable employment for many people. Let me say right here that Peter Van Buren, the son, succeeded the original John, and was followed by his son Isaac in the fisheries. The latter lives to-day in a pleasant frame farm house, on the same spot where the first log-hut was erected years ago near Battle Island, famous in history.

HISTORY OF THE INDUSTRY.

There are five great fisheries on the Oswego River and its tributaries, situated at Battle Island, Fulton, Horseshoe Dam, Jack's Rifts, and Caughdenoy. Battle Island, where the fisheries originated, has been continuously fished for over eighty years. Mr. Charles Peckham, a lock tender on the Oswego canal, who now rents the weirs there, gave me the information concerning the fishery, which is here reproduced in brief. The best catch was obtained in 1836, when $800 worth of eels were secured, an equivalent of 11,500 pounds dressed. For several years past the catches have been light, not worth over $200 per year, owing to the water which has never been so low as during 1880. The market for this fishery is chiefly now among the canal boats. Eels are also shipped to Fulton, four miles distant, and Oswego, eight miles away. The following table gives the best approximate result of the fishery for eighty years that could be obtained:

	Value.	Pounds.
Greatest haul, in 1836	$800	11,428
Least catch, in 1880	200	2,857
Average per year	$500	

Eighty years at $500 per year, equals $40,000, an equivalent of 571,000 pounds of dressed eels, or 381,000 live eels. An average value of seven cents per pound is made use of here, which value is generally agreed upon by all fishermen.

FULTON

At Fulton, Lewis Fuller has fished since 1846. The river has been fished here for fifty years. The following statistics were secured at this point:

	Value.	Pounds.
Greatest catch, in 1862	$1,400	20,000
Least catch, in 1880	200	2,857
Average	$800	

Fifty years at $800, is equal to $40,000, an equivalent of 571,000 pounds of dressed eels, or 381,000 live eels.

The largest catch ever made at this point was 1,150 pounds in one night, an equivalent of 800 live eels. The number of live eels are obtained in this manner: an average eel weighs two pounds. One-third of this is lost in dressing. Now, to the number of pounds of dressed eels add one-third the weight and divide the result by two, which will give an approximate idea of the number of live eels. The markets for Fulton eels are Rochester, Buffalo, Syracuse, Oswego, Chicago, and Fulton. Chicago receives its supply mainly from eels shipped to Syracuse, the greater shipments being in cold weather.

HORSESHOE DAM.

Horseshoe dam is situated four miles above Fulton, and is fished by Lewis and Levi Montague. It has been fished for sixty-five years, and has an average value of $850 per year in its fisheries—an equivalent of $55,000 for that length of time, 790,000 pounds of dressed eels, and 475,000 live eels.

JACK'S RIFTS.

"Jack's Rifts" are situated on Seneca River about four miles up from its junction with the Oneida River, which streams together combine to form the Oswego River. It is a small fishery, which has had an existence of twenty-five years. It is the property of James Devlin, and I understand has had an average value of $300 per annum, an equivalent of $7,500—110,000 pounds of dressed eels and 72,000 live eels.

CAUGHDENOY.

The most important of these fisheries are situated at Caughdenoy on Oneida River, twelve miles from its junction with the Oswego River. They have been active for fifty years. There are some twenty men at work here day and night, who run ten weirs. One firm is composed of Jefferson and Neil Hopkins, David Buss, and Frank Palmerton. It has operated for twenty-two years. Their largest catch was in 1874, when $1,000 worth of eels were secured. The fishery for the specified time has produced $15,000, an equivalent of 160,000 pounds of dressed and 107,000 live eels. The markets for these fisheries are Fayetteville, Syracuse, Rochester, and Amsterdam. Wm. Rhines has fished for nine years here, for which he has received $2,000, an equivalent of 22,000 pounds of dressed and 14,000 live eels. Messrs. Guard & Van Antwerp have fished for fourteen years, for which they have obtained $5,000, an equivalent of 55,000 pounds of dressed and 36,000 live eels.

The following table shows the approximate value of the combined fisheries for Caughdenoy.

	Value.	Pounds.
Known value for 22 years (equal to 158,000 live eels.)	$22,000	314,000
Approximate value for previous years (equal to 170,000 live eels.)	28,000	400,000
Total	$50,000	714,000
		475,000 live eels.

The following table shows the value and extent of the entire industry of the Oswego River.

	Value.	Lb. eels dressed.	No. live eels.
Fishery at Battle Island for 80 years	$40,000	571,000	380,000
Fishery at Fulton for 50 years,	40,000	571,000	380,000
Fishery at Horseshoe Dam for 25 years	55,000	790,000	475,000
Fishery at Jack's Rifts for 25 years	7,500	110,000	72,000
Fisheries at Caughdenoy for 50 years	50,000	714,000	475,000
Total	$192,500	2,756,000	1,782,000
Average per year, 52 years,	3,500	55,000	35,000

PHYSICS OF THE RIVER.

The physics of the Oswego River has been a peculiarly interesting study to me. I have already covered the subject in an article published in the *American Naturalist* for February, 1880, entitled "Water Sheds of the State of New York," from which I take the following information:

"The most powerful water shed of the state is drained by the Oswego River. Its area contains no less than seven thousand square miles of territory. It comprises the well known chain of lakes, some of which are of considerable size and importance—the Oneida, Cayuga, Seneca, etc., amounting to over four hundred square miles of lake surface. Besides being in themselves natural reservoirs, the State has further improved Seneca lake so as to regulate the periodical flow of the water. The average flow of the water is thus secured at about 600,000 cubic feet per minute. Twenty miles above the mouth of the Oswego River is Three River Point. From this place, down stream, there is a fall of water amounting to seventy-five feet. This space is taken up by seven dams erected and maintained by the State. Of these, two are situated at Oswego, covering a fall of forty feet. These dams accord hydraulic privileges equal to 25,000 horse power. But a moderate outlay is required to keep the flow in the river near the average for the year. 150,000 cubic feet of this water supply is in actual use in Oswego, where the canals are provided for the reception which furnishes 82 runs of first-class water, and 37 of the second class.

"Two dams are situated at Fulton with 20,000 horse power. At this point the water privileges are easiest available, although Oswego has the greater representation of industries.

"The Oswego River water shed produces clear cold water, which is perfectly under control of man, no matter what the circumstances or exigencies. The river bank forms a line teeming with industries, with millions of dollars invested. This water supply never endangers the lives of citizens or encroaches on their property, but on the contrary, affords a roadway for inland navigation through the canals which it feeds."

FISHING APPARATUS.

It will be seen from the above that this great body of water has a tremendous current. It is in the rapids and swift places that the weirs by which the eels are caught are set. A weir, I may say to those who are unacquainted with its structure, is a large sieve, or oblong box, about 12 by 8 feet in size, open at the top and one end, with a bottom of slats so arranged that the water may pass through. Fences, made eel tight—that is, so constructed that water, but not eels may pass through them, are run diagonally down from opposite sides of the river. The weirs, sometimes two, and again one, are placed in the intersections of the fences or leads. Eels are said to always run down stream, and when they arrive at a fence they take a lightning speed which throws them at the gates out into the weirs, where a man usually stands to capture them. The apparatus has been rendered in part useless during the past summer by an unprecedented season of low water. It will be remembered that a great drought has prevailed in the East this year, which accounts for it. The State reservoirs were not sufficiently large to provide for such a season. Though quite low in 1873, it was lower on Sept. 18, than it has been since 1849. Besides the drought, other causes conspire to make low water. The Oswego River is lined with great manufacturing interests, which require a large portion of the water to keep them running. The effect of these is more and more marked as one travels up the river. Low water has made eels scarce. No fisherman can count on more than from two to four hundred dollars' worth of fish this season. In fact careful estimates show a gradual falling off both in the eel and water supply for several years past.

SEX IN EELS.

There is no longer any question as to the difference between sexes in eels. The males are usually small and poor. On account of this fact, few are taken by the fishermen. Being small they either escape through the weirs and fences, or are thrown out by the fisherman "to grow," as they say. One fisherman whom I asked if he had ever seen a male eel, stated that he had examined the stomachs of a great many eels, but had never seen one. The reason why, is obvious. In the first place he always examined the largest female he could find, and in the next the organs of generation in the male are microscopic forms, hardly visible to the unaccustomed eye. There were three eels at the Exposition just closed in this city, all of which, I believe, were males.

SPAWNING GROUNDS.

Mr. Sawyer, in the New York *Times* article alluded to, shows conclusively that *all* eels do not go to the sea to breed. I am convinced, first, that eels do not breed in the ocean; second, that some breed well inland. I base my first opinion on well authenticated evidence that large eels are seldom found in the ocean, and that eels prefer and do breed in the deep mud at the mouths of rivers, at the head of high tide. Further on the ocean breeding of eels I have nothing to offer. As to their breeding inland I have satisfactory (to me) proof. First, on the evidence of Mr. Sawyer, who claims to have found them breeding in a pond near Saw-Mill Bift, Delaware, his home.

I am convinced that eels breed in the Oneida Lake, for these reasons: The fishermen alluded to in this paper generally state that eels breed there; it is a great resort for the fish, and they are seen here in large numbers during low water. In August the fishermen say the eels are "on the grass," to use their own expression. Few eels are ever caught in this month, the best fishing being from May into July, and from September through October. By "on the grass" the fishermen mean that in July they find them often in balls like snakes, into which a spear is thrown, and many secured at once. They are found at this time among what is known as eel grass. Here they congregate and become pregnant. The eel grass grows in the soft mud with other weeds. The fisherman described to me a "jelly-like substance," as they say, in chunks the size of the two fists, which they find here occasionally in the early winter, which, from their description, is probably eel spawn.

Mr. Fuller described to me his experience with some of this spawn. He reserved a place on the edge of the river near his fishery at Fulton. He watched the growth of the minute fishes in embryo. One morning he visited his miniature pen to discover that the young fry had escaped. True to their instinct, the young eels had crawled out of their pen on their first exit from their confinement as embryos. It is a well established fact that young eels are adepts in scaling almost any dam. Mr. Wesley, of Evanston, an old English fisherman, related to me several days since how forty years ago he used to watch young eels in springtime climb the rocks damming a small stream in the old country. Their breeding habits were familiar to him as far back as 1830. His statements are entirely confirmatory to the fact of their spawning in part in tide waters.

But reverting again to the inland eels, it will require nothing less than a marked female, let loose in Oneida Lake and caught in the act of spawning in the tide waters of the St. Lawrence River, to convince me that these eels travel 800 or 1,000 miles to breed.

As to young eels the fishermen have never seen them running up stream in the river in question, nor in the river at all. Every fisherman with whom I conversed claims that the eel breeds in Oneida Lake. To cap the summit of my beliefs I will say that as soon as I began to arrange my material for this paper I examined all my scientific data gathered through years, I might say since I was fifteen years of age, and found that in the spring of 1874, a friend and myself observed little eels, scarcely two and one-half inches in length, among the eel grass of a mill pond on Little Salmon River, at Mexico, Oswego county, New York.

The following characteristic letter received a few days since tends to confirm the above:

HERMANVILLE, N. Y. (HORSESHOE DAM), Oct. 31, 1880.

WM. H. BALLOU, Evanstown, Ill.

DEAR SIR: I received your letter in regard to catching eels with pleasure. I have taken these fish here for forty-one years. My father commenced fishing after the war of 1812, and continued until he was sixty-five years old. In 1864 I made $1,400, and this year will not receive more than $300. The greatest catch I ever made in one night was 1,400 pounds. I have five weirs. The Leather Stocking Club of sportsmen made such disturbance that I did not accomplish much during the fore part of the season. I know that eels breed in Oneida Lake. They hang on the eel-grass there three or four days in the month of August. That is the time they become pregnant, for I never saw any preliminary signs of breeding at other times. I kept one man in my employ. I sent eels as far East as Albany last year, and have sent to to your city (Chicago) and Philadelphia this summer. . . .

Yours truly, LEWIS MONTAGUE.

SCARCITY AND PLENTY.

I have already stated that for several years past eels have grown less and less in numbers, and that it was in part due to the drought and absorption of the water by the mills. Let me elaborate. The average flow of the Oswego River is 600,000 cubic feet per minute. The water is a foot lower this season than low water mark, reducing this flow from the average to not more than 400,000 cubic feet per minute.

This drought has, no doubt, destroyed many eels, because, as I shall show hereafter, they can live on water alone for a long time, and it is necessary to have a good and fresh supply to insure their keeping. Another note is this: eels are taken most plentifully in heavy rainstorms. They spend much time in the mud. Consequently when it rains the water is roiled, and true to their instinct, they are not disposed to distinguish the difference between it and the soft mud. Since it has not rained during the last summer they have retired deeper and deeper into the mud to exist, and have not run in any numbers. The extent of this mud in these inland lakes is this: I have seen the top end of a fifteen foot pole disappear from sight in it, without much effort on the part of the experimenter. I consequently think that the eels are not disappearing from the river, but are simply awaiting heavy rains to appear again in vast numbers. I should not be surprised if any excessive breeding during the past summer had been prevented by the drought.

FOOD OF EELS.

The food of eels forms an interesting study. They are among the most voracious of carnivorous fishes They eat

* A paper read by Wm. Hosea Ballou before the Chicago Academy of Science, on Tuesday evening, Dec. 14, 1880.

most inland fishes except the garfish and the chub. Investigation of 600 stomachs by Oswego River fishermen showed that the latter bony fish never had a place on their bill of fare. They are particularly fond of game fishes, and show the delicate tast of a connoisseur in their selections from choice trout, bass, pickerel, and shad. They fear not to attack any object when disposed, and their bite in human flesh shows even a vicious attitude toward man. On their hunting excursions they overturn huge and small stones alike, working for hours, if necessary, beneath which they find species of shrimp and cray-fish, of which they are exceedingly fond. Of shrimps they devour vast numbers. Their noses are poked into every imaginable hole in their search for food, to the terror of innumerable small fishes.

Eels are to the water what the fish hawk is to the air. They are perhaps the most powerful and rapid of natatorians. Again, they hide in the mud beneath some log or overhanging rock and dart out with tremendous fury at the unsuspecting prey. They attack the spawn of other fishes open-mouthed, and are even said to suck the eggs from an impaled female. They fearlessly and rapidly dive head foremost in the mud, disappearing from view in the twinkling of a star. They are owl-like in their habits, committing many of their depredations at night.

EELS AS FOOD.

No fish is yet reported to utilize a grown eel as food. Pickerel, garfish, and bass, which are particularly numerous in these lakes, are supposed to literally devour the young fry. Mr. Sawyer describes the operation of the pickerel darting through a long column of young eels, open-mouthed, and devouring vast numbers of them.

As a food for man the eel is a favorite to those who have tasted its meat smoked. Eels are shipped smoked, dressed, and alive. Previous to being smoked they are salted for twenty-four hours, freshened and smoked over a cob fire from two to three hours. When dressed they are opened on the abdomen, skinned, and shipped in powdered ice. When shipped alive they are packed in a barrel, with a chunk of ice, in which way they will keep twenty-four hours alive, and often longer.

NATURAL HISTORY NOTES.

Endurance.—The subject referred to last brings up an incident. On my return from Caughdenoy to Fulton, one of the hottest days in summer, I put an eight-pound female eel in a small air-tight wooden box. In this manner I kept it some five hours, carried it twenty miles on the cars, and put it in a large tub of water, where it lived thirty-six hours.

On this subject Frank Buckland writes in *Land and Water:*

"The eel, as is well-known, will live a long time out of water. This habit is of the greatest service to him, as sometimes it is necessary for him to migrate from place to place by an overland route. To enable him to live out of the water the eel has a most elaborate yet simple form of mechanism, by means of which he is enabled to keep his gills moist even though he is not in the water. It will be observed that immediately, or if not very soon after, an eel is taken out of the water, two great swellings will take place on each side of the head, and if the eel is placed back in the water this swelling will immediately disappear. Let us now take a dead eel; we shall find close to the pectoral fin a slit in the skin which acts as a valve. If we take a probe and pass it through this slit we find that it enters a large cavity; next, take a pair of scissors and cut open this cavity; inside we shall find the gills proper. It is this cavity which the eel has the marvelous power of filling with water, and keeping a supply which shall not allow the gill fibers to adhere together, and thence of necessity stop respiration. This cavity is, of course, made of a large and loose skin-like membrane, which holds the required quantity of water; but in order to enable him to fill and empty this cavity, an elastic yet firm mechanism of some kind is absolutely necessary.

See for yourself what a beautiful piece of machinery is provided by the Creator. A framework of very delicate bones, each bone connected with its neighbors by an elastic membrane of the consistency of gold beater's skin, forms a fan-shaped covering over the gills; its action is very like, if not exactly the same as, the action of an umbrella. When the eel wishes to take in his water supply he, as it were, opens the umbrella shaped framework and fills his reservoir; when he wishes to expel the water he, as it were, closes his umbrella, as his reservoir is no longer required to come into action.

If an eel be taken out of the water and laid on the floor of a room, and left there for some time, it will be seen that he will very soon expand his reservoir. After a time he will be desirous to refill his reservoir; take him up, and put his head into a basin; you will see that he will immediately take two or three great gulps so as to restock his breathing bags. It is by this beautiful piece of mechanism that the eel is enabled to live so much longer out of water than any other fish; and also, as I have stated before, to shift his quarters when it is desirable to do so.

Mr. Hopkins, of Caughdenoy, told me that a dozen eels were kept in a crate anchored in the current for ten months without food. At the end of that time the box was let loose by a flood and is floating now, for aught I know. The incident illustrates the fact that fresh water is the staple food of the eel, particularly the female. The eels were boxed for the express purpose of experimenting on breeding. Unfortunately the largest specimens were selected for the experiment, which were of course entirely females. I believe that if both males and females were put in a large water crate, and arranged with soft mud and weeds on the bottom, they would breed at the proper time.

Tenacity.—When an eel gets into a slit in a weir, it squirms to get through. They are wedged in so tight sometimes that the fisherman simply cuts off and saves the part remaining above the slits.

The largest eel ever taken by the fishermen weighed twelve and one-half pounds, and was caught at Horseshoe Dam.

A large catch on any particular night in the fall is regarded as foretelling a frost by fishermen.

The length of life in the eel is practically unknown.

In conclusion, permit me to say in behalf of the now persecuted fishermen of the Oswego River and the State of Delaware:

That I believe their fence dams are of great benefit to the State in holding back and retaining the water when it is low;

That the eel is a terrible enemy of game fish, particularly bass and trout, and its extermination is advantageous to the protection of those fish;

That the sportsmen of Northern New York who are endeavoring to pass laws to harass or break up the fisheries, are common enemies of a lawful industry, the interests of science, and the most enlightened views of this enlightened age.—*Chicago Field.*

ALKALI WASTE AS A MANURE.

At a recent meeting of the Farnworth Agricultural Society, Mr. Gossage called the attention of the farmers present to the value of alkali waste as a manure. This substance is well known to have accumulated in the Widnes District to a serious extent, and any method by which it might be utilized or even got rid of would prove a great boon to the neighborhood. Mr. Gossage informed his hearers that alkali waste consists of calcium sulphide and sulphate, the former ingredient rendering it a valuable application for land foul with weeds, noxious insects, etc., while the sulphate, otherwise known as gypsum, fixes ammonia and decomposes the alkaline silicates of clay soils, thus rendering their potash available for the demands of vegetation. He recommends it to be applied to the extent of about twenty-five to fifty tons per acre, being spread evenly over the fields early in the autumn, and left to lie for a month or six weeks before being plowed in. He adds the caution that a sufficient time must be allowed to pass over before any seed is sown in land which has been thus treated. As, however, the production of alkali waste at Widnes amounts to 1,000 tons daily, it appears doubtful if a sufficient quantity of land requiring such dressing is to be found within prohibitive distances. Nor must it be forgotten that the constant application of a manure which supplies neither nitrogen, phosphoric acid, nor potash, cannot be long continued. From the fact that fresh applications have still to be sought for alkali waste, it may be inferred that the success of the processes for the regeneration of the sulphur present is less decisive than might be wished.

LAWN GRASSES.

A LAWN always handsome adds great beauty to any country or village residence; but the matter of making and keeping it so is found some trouble by many. We have mixtures of seeds, sold by seedsmen, claimed to be specially adapted to the lawn, but they often fail to prove entirely satisfactory. A better result is often attained by simply relying upon manuring with manure from stock fed on old meadow hay. Either of the following grasses will give alone a fine sod, and often succeed where other varieties will not: *Poa annua*, a soft, dwarf grass, common around back doors of old residences, foot paths, and shaded places, will often succeed in places where no other grass will grow, such as on the northerly side of buildings, or beneath the drip of trees. It also thrives admirably in shaded angles much trodden. Probably the seed of this little poa (which is true to name), sold in this country, is imported. A small quantity of seed suffices to cover the ground in a few years, where there is sufficient richness of soil. The other species is that very common wayside grass, a species of red-top, which differs from ordinary red-top (*Agrostis*), as sold in the seed stores, in size and character of growth. This grass is specially adapted for dry and gravelly soils not abundantly supplied with manure, but is easily destroyed by plowing, although it will bear closer feeding than *Poa pratensis.* The annual poa is claimed by botanists to be an annual, but it can hardly follow the law of common annuals, as it will continually reproduce itself when cut with the lawn-mower. May there not be reason to believe that some other plants, if not allowed to seed heavily and often cut, will survive more than one winter? A thin soil, heavily manured in spring, induces a rank growth, requiring frequent cuttings, expending the necessary store of water in the soil, showing often withered spots by August and September.—*W. H. White, in Country Gentleman.*

WHAT TO DO WHEN AT A LOSS.

SPEAKING of the recognition of the forms of disease, Dr. S. Weir Mitchell has used, in one of his gracefully written popular articles, the admirable simile that the faint indications of the nature of a malady are, at its outset, as if we saw only the first one or two letters of a word, and were seeking to read it all. These initials enable us only to classify it under some wide rubric, not to identify it; we wait hours or a day and other symptoms arise. We see other letters of the word, and as one after another is revealed the import and full meaning of the whole at length is disclosed.

But we cannot stand idly by and wait until our information is complete before we lend a helping hand. Something must be done at once; something useful, beneficial, at least not harmful. Many a time does the physician find himself in this predicament. He sees the case early; he can form no diagnosis, but he is called upon to prescribe. Beginners especially find themselves at a loss on such occasions.

Some years ago Dr. Robert Barnes, of London, delivered a quaint lecture, in which he faced this difficulty. From his solid suggestions and from some other sources, we believe we can advance with confidence some general rules which will serve a good turn at a pinch. The first rule to be adopted is to—

Enjoin rest. This is a good rule; good for the patient and good for the physician. The Pharmacopœia contains no remedy of so much value and of such universal application. At the outset of many an acute complaint rest to the part and to the system is all that is demanded to insure recovery, safely, speedily, and comfortably. It has also its advantages for the medical attendant. It gives him time to observe leisurely and to watch under favorable conditions the development of ulterior symptoms. It is obvious, however, that it is not enough to satisfy the expectations of the patient, no matter how much it satisfies all the requirements of the case. The doctor is expected to *give something;* to administer some of the contents of those mysterious and attractive bottles and jars which adorn the shelves of his right-hand man, the apothecary. Barnes' rule is, here—

When in doubt, give salines. He wisely observes that there is hardly any disease in which salines will not do good in the beginning. What is not less important, there is hardly any disease in which they will do harm. They give favorable relief to general and local congestion, and they afford time for observation. Moreover, their variety is great, and their strength can be adjusted to the demands of the most delicate cases. The third rule may be to

Relieve any organ functionally disturbed. This, however, requires to be admitted with some exceptions, and to be carried out with discretion. For example, it is not always wise to purge when the bowels are constipated. On the contrary, opium may be indicated, as in intussusception. The relief of the organ may often be brought about with better success by indirect measures. Thus, an engorged liver is most promptly relieved by stimulating the functions of the kidneys; and numerous examples of the kind will occur to every reader. The fourth rule is to

Avoid committing yourself. As it is often impossible positively to know the complaint before you, it is equally essential neither to express a decided opinion nor to let it be seen that you have none. A mistake made at this moment on either side will be damaging. Those who boast that they can see through a disease at a glance are shallow people, and but one step above those quacks who advertise to tell the complaint without asking the patient a question. Nothing is lost, and often everything is gained, by *thoroughness.* The soundest physicians are those who proceed warily. The last and greatest as well as the oldest maxim to be observed is that which we owe to Father Hippocrates. It is to

Do no harm. If none of the above precepts seem applicable to the case before you, at any rate take care that you do nothing to aggravate the condition of your patient. Recollect that there is at least a grain of truth in the satirical remark quoted by Mr. Francis Galton, in his "Art of Travel," to the effect that there is a great difference between a good physician and a bad one; but very much less between a good physician and none at all.

If an observance of the above does not carry the neophyte through the awkwardness of all his first visits, and spare to the more experienced an occasional attack of worriment, they will, at least in many instances, help him through a slough of doubt.—*Med. and Surg. Reporter.*

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